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ART. XLIX.—*The Sufficiency of Terrestrial Rotation for the Deflection of Streams;* by G. K. GILBERT.

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IT was long ago perceived that rivers flowing to the north or to the south should by the rotation of the earth be thrown severally against their east or west banks. It is even many years since it was shown by Ferrel that these tendencies are but illustrations of a more general law, that all streams in the northern hemisphere are by terrestrial rotation pressed against their right banks, and all in the southern are pressed against their left banks, the degree of pressure being independent of the direction of flow. Yet the question of the sufficiency of the cause for the production of observable modifications in the topography of stream valleys is still an open one. A number of geologists have observed peculiarities of stream valleys which they referred to the operation of the law, while others, including myself, have looked in vain for phenomenal evidence of its efficiency. Nevertheless, it is my present purpose to maintain the sufficiency of the cause.

So far as I am aware, all those who have attempted to consider analytically the mode in which the lateral tendency arising from rotation should modify the channel or valley of a stream have reached the conclusion that no appreciable results can be produced, and for the most part their conclusions legitimately follow their premises. My own different conclusion is based upon an essentially different analysis of the

processes involved. In the celebrated discussion in the French Academy of Science, it was computed by Bertrand that a river flowing in N. lat. 45° with a velocity of three meters per second exerts a pressure on its right bank of $\frac{1}{6\,3\,5\,3\,9}$ of its weight, and he regarded this pressure as too small for consideration. It has been pointed out by Henry Buff that the deflecting force, by combining with gravitation, gives the stream's surface a slight inclination toward the left bank, thereby increasing the depth of water near the right bank, and consequently increast ing the velocity of the current at the right. To this increment of velocity he ascribed a certain erosive effect, but regarded it as less than that assignable to wind-waves on the same water-surface. He therefore accorded a more important influence to the prevailing winds than to the rotation of the earth. It has been held by others that the combination of the deflective force with gravitation is equivalent simply to a slight modification—so far as the stream is concerned—of the direction of gravitation; and that, the flood-plain of the stream having been adjusted normal to this modified direction of gravitational attraction, no other geological effects are produced. The last was my own view until I perceived the importance of certain considerations to which I now proceed.

The form of cross-section of a stream flowing in a straight channel depends on the loading and unloading of detritus and is essentially stable. It is evident that the form of the cross-section controls the distribution of velocities of current within its area, and that through the interactions of these velocities its parts are interdependent. Each element of its curve is so adjusted to the adjacent current and to the detrital load of the stream that it can neither be eroded nor receive a deposit, and the stability of the profile depends on the fact that an element not adjusted to the contiguous current and load becomes subject either to erosion or to deposition until an adjustment is reached. The distribution of velocities within the cross-section is symmetric, the swiftest threads of the current being in the center and the slowest adjacent to the banks.

If, now, curvature be introduced in the course of the channel, centrifugal force is developed. This centrifugal force is measured by the square of the velocity, and is therefore much greater for swift central threads of the current than for slow lateral threads. As pointed out by Thomson and others, the central threads, tending more strongly toward the outer bank, displace the slower threads of that bank, and the symmetry of distribution of velocities is thus destroyed. In other words, the centrifugal force developed by curvature exercises a selective influence on velocities, and transfers the *locus* of maximum velocity from the center of the channel toward the outer bank.

The conditions of symmetry in the profile of the cross-section are thus destroyed. The outer bank is eroded; a deposit is accumulated on the inner bank. Moreover there is no compensating tendency to restore an equilibrium, for the erosion of the outer bank increases the sinuosity of the channel instead of rectifying it.

Curvature of course thus causes a stream to shift its channel laterally, and in this manner enlarge its valley. It is the most important condition of lateral corrasion.

As shown by Ferrel, the deflective force due to terrestrial rotation varies directly with the velocity of the stream. It therefore has a selective influence on the velocities within the cross-section of the channel; and it too tends to produce erosion at one side and deposition at the other. For a given amount of deflective force its selective power is only half as great as that of the centrifugal force developed by curvature of course, for centrifugal force varies with the second power of the velocity while the rotational deflective force varies only with the first power. But its selective power is of the same kind and may be quantitatively compared. For the purpose of this comparison I will develop an equation:

Let F=deflective force, per unit of mass, due to rotation.
n=angular velocity of the earth's rotation.
v=velocity of stream.
λ=latitude of the locality.
ρ=radius of a curvature of the stream's course.
f=the centrifugal force, per unit of mass, developed by such curvature.

$$\text{Then } f=\frac{v^2}{\rho} \quad - \quad - \quad - \quad - \quad (1)$$

and, from Ferrel,

$$F=2vn \sin \lambda \quad - \quad - \quad - \quad - \quad (2)^*$$

Let v_r=velocity of a rapid-flowing thread of the current,
v_s= " " slow " " " "

Represent by F_r, F_s, f_r, and f_s the corresponding deflective forces due to rotation and curvature,

$$\text{then } F_r-F_s=(v_r-v_s)\times 2n \sin \lambda \quad - \quad - \quad (3)$$

$$\text{and } f_r-f_s=\frac{v_r^2-v_s^2}{\rho} \quad - \quad - \quad - \quad - \quad (4)$$

F_r-F_s evidently expresses the selective power due to curvature; f_r-f_s similarly expresses the relative power due to rota-

* This Journal, II, xxxi, 29, equation (5). Ferrel's expression is modified above by the substitution of the sine of the latitude for the cosine of the polar distance.

tion. Where the curvature has a convexity to the right, these two influences conspire, and their resultant is deducible by addition. Where the curvature has a leftward convexity the influences are opposed, and their resultant is deducible by subtraction. [The terminology here and through the remainder of the paper is adjusted to the northern hemisphere exclusively.] If we represent by R the joint selective power on curvatures of right hand convexity and by L the joint selective power on curvatures of left hand convexity, then we deduce by simple combinations and transformations of equations (3) and (4).

$$\frac{R}{L}=\frac{v_r+v_s+2\rho n \sin\lambda}{v_r+v_s-2\rho n \sin\lambda} \quad - \quad - \quad (5)$$

v_r and v_s may be the velocities of any two threads of current moving at different rates, but for purposes of convenience and simplification we now assume that they are symmetrically related to the mean velocity v; and introducing this relation in (5) we obtain

$$\frac{R}{L}=\frac{v+\rho n \sin\lambda}{v-\rho n \sin\lambda} \quad - \quad - \quad (6)$$

This equation expresses the ratio between the selective influences tending to determine the maximum velocity toward the right and left banks respectively of a meandering stream. Since these tendencies result in erosion, the ratio is a function of the tendency of a stream to erode its right bank as compared with its tendency to erode the left.

For the purpose of securing a quantitative result the Mississippi River will be used in illustration. In its lower course the sharpest bends have a radius of curvature, measured to the center of the channel, of about 8,000 feet. These curves, together with all other channel features, are determined by the water at its flood stage. It is therefore proper to consider in this connection the mean flood velocity. That was determined by Humphreys and Abbott to be, at Columbus, Kentucky, 8·4 feet per second. The latitude of the locality is 37°. Giving these values to ρ, v, λ, and substituting for n its numerical value ·000072924, we obtain from (6)

$$\frac{R}{L}=1{\cdot}087$$

The selective tendency toward the right bank is therefore nearly nine per cent greater than toward the left.

With the elements of another stream it is probable that a very different result would be obtained; but this single example suffices to show that while the influence of rotation is small, as compared to that of curvature, it is still of the same order

of magnitude, and may reasonably be expected to modify the results of the more powerful agent. In the present state of hydraulic science it is impossible to define the quantitative relation between the tendency of swift threads of current toward a bank and the consequent erosion; but whatever that relation may be, I conceive that rotation is competent to produce appreciable results wherever those due to curvature are great.

It will be observed that the efficiency of rotation thus advocated is only in connection with, and as an adjunct to, lateral wear by means of curvature. There are two general cases, including a large share of all streams, to which the conclusion does not apply. (1.) A stream which rapidly corrades the bottom of its channel does not notably corrade its banks; and in such case the effect of rotation should not be discoverable. (2.) A stream engaged in the deposition of detritus, as on a delta or an alluvial fan, shifts its channel from side to side by a process entirely distinct from the one just described. It builds up its bed until it is higher than the adjacent plain, and then transfers its current bodily to a different course. Rotation has its share of influence in determining the direction of this transfer, and it thereby induces the stream to build its alluvial plain higher on the right than on the left; but, the difference of level having been established, the stream has thereafter no more tendency to one side than the other. Deflective effects of rotation are therefore not to be sought in regions of alluvial deposition.

It may be remarked also that the tendency of a stream toward one bank or the other by reason of curvature and rotation is often overpowered by an opposite tendency due to obstructions. These include resisting members of the eroded terrane and alluvial dams deposited at one bank or the other by tributaries.

A general curvature in the course of the valley through which the stream flows has the same tendency, though in a less degree, as does the curvature of a short bend, and this tendency must in many instances nullify or conceal the results of rotation.

Visible examples of the work of rotation are therefore to be sought especially in streams which, with courses in the main direct, are slowly deepening their valleys by the excavation of homogeneous material. The best locality of which I have any knowledge is one to which attention was called by Mr. Elias Lewis in this Journal for February, 1877, and which has recently been visited at my request by Mr. I. C. Russell. The south side of Long Island is a plain of remarkable evenness, descending with gentle inclination from the morainic ridge of

the interior to the Atlantic ocean. It is crossed by a great number of small streams which have excavated shallow valleys in the homogeneous modified drift of the plain. Each of these little valleys is limited on the west or right side by a bluff from ten to twenty feet high, while its gentle slope on the left side merges imperceptibly with the general plain. The stream in each case follows closely the bluff at the right. There seems to be no room for reasonable doubt that these peculiar features are, as believed by Mr. Lewis, the result of terrestrial rotation. As the streams carve their valleys deeper, they are induced by rotation to excavate their right banks more than their left, gradually shifting their positions to the right and maintaining stream cliffs on that side only.

ART. L.—*Examination of Mr. Alfred R. Wallace's Modification of the Physical Theory of Secular Changes of Climate;* by JAMES CROLL, LL.D., F.R.S.

[Continued from page 93.]

PART II.—*Geological and Paleontological Facts in relation to Mr. Wallace's Modification of the Theory.*

MR. WALLACE'S chief, and indeed only real modification of my theory, is to the effect, as I have pointed out, that the alternate phases of precession causing the winter of each hemisphere to be in aphelion and perihelion each 10,500 years would produce a complete change of climate only when a country was partially snow-clad. According to his view, when the greater part of Northwestern Europe was almost wholly buried under snow and ice, those glacial conditions must have continued, and perhaps have even become intensified, when the winter solstice moved round to perihelion, instead of being replaced, as I have maintained, by an almost perpetual spring. In short, Mr. Wallace's conclusion is that, during the Glacial Epoch proper, a warm and equable Interglacial Period could not have occurred.

In the preceding part of this paper I have endeavored to show that physical principles do not warrant such a conclusion. I shall now proceed to consider what the direct testimony of Geology and Paleontology is on the subject; and I believe we shall find that the facts of Geology and Paleontology are as much opposed to the conclusion as are the principles of Physics.

On this point I may quote the evidence of a geologist who, more than any other, has devoted special attention to all points relating to Glacial and Interglacial periods. Prof. J. Geikie, after devoting upwards of 500 pages of his 'Prehistoric Europe'

to the consideration and accumulation of facts from all parts of this country and the continent relating to Glacial and Interglacial periods, gives the following as the result of his investigations:—

"We note," he says, "as we advance from Pliocene times, how the climatic conditions of the colder epochs of the Glacial Period increase in severity until they culminate with the appearance of that great northern *mer de glace* which overwhelmed all Northern Europe, and reached as far south as the 50th parallel of latitude in Saxony. Thereafter the glacial epochs decline in importance until in the Postglacial Period they cease to return. The genial climate of Interglacial ages probably *also attained a maximum* toward the *middle* of the Pleistocene Period, and afterwards became less genial at successive stages, the temperate and equable conditions of early Postglacial times being probably the latest manifestation of the Interglacial phase." ('Prehistoric Europe,' p. 561.)

I shall now quote the same author's description of an Interglacial Period as demonstrated by its flora and fauna. The reader must, however, observe that by Pleistocene Period, Professor Geikie means the so-called Glacial Period with its alternations of severe arctic climate and mild and genial conditions. See p. 544, 'Prehistoric Europe.'

"An examination," he says, "of Pleistocene organic remains leads us to conclude that strongly contrasted climatic conditions alternated during the Period. At one time an extremely equable and genial climate prevailed, allowing animals, which are now relegated to widely-separated zones, to live throughout the year in one and the same latitude. Hippopotamuses, elephants and rhinoceroses, Irish deer, horses, oxen and bisons then ranged from the borders of the Mediterranean as far north at least as Middle England and Northern Germany. In like manner, plants which no longer occur together—some being banished to hilly regions, while others are restricted to low grounds, and yet others have retreated to the extreme south of the Continent or to warmer regions beyond the limits of Europe—lived side by side. The fig-tree, the judas-tree, and the Canary laurel flourished in Northern France along with the sycamore, the hazel, and the willow. And we encounter in the Pleistocene deposits of various countries in Europe the same remarkable commingling of northern and southern forms—of forms that demand a humid climate and are capable of enduring considerable cold, together with species which, while seeking moist conditions, yet could not survive the cold of our present winters. The testimony of the mammals and plants is confirmed by that of the land and freshwater mollusca—all the evidence thus conspiring to demonstrate that the climate of

Pleistocene Europe was, for some time at all events, remarkably equable and somewhat humid. The summers may not indeed have been warmer than they are now; the winters, however, were certainly much more genial." ('Prehistoric Europe,' p. 540.)

This, be it observed, is a description of a condition of things which existed during an interglacial period belonging, not to the close, but to the very climax of the Glacial Epoch. For immediately preceding and succeeding this Period almost the whole of Northern Europe was enveloped in one continuous sheet of ice. "But if," continues Professor J. Geikie, "the evidence of such a climate having formerly obtained be very weighty, not less convincing are the proofs, supplied by the Pleistocene deposits, of extreme conditions. Think what must have been the state of middle and Northern Europe when Paleolithic man hunted the reindeer in Southern France, and when the arctic willow and its congeners grew at low levels in Central Europe. Reflect upon the fact that in the very same latitude in France, where at one time the Canary laurel and the fig-tree flourished, the pine, the spruce, and northern and high-alpine mosses at another time found a congenial habitat. Bear in view, also, that the land and freshwater mollusks testify in like manner to the same strongly contrasted climate. Besides those that tell of more equable and genial conditions than the present, there are species now restricted to the higher Alps and northern latitudes that formerly abounded in middle Europe, and their shells occur commingled in the same deposits with the remains of lemmings, marmots, reindeer, and other northern and mountain-loving animals." (p. 541.)

But more convincing still is another range of facts, some of which have been adduced by Mr. Wallace himself. In a section on alternations of warm and cold periods during the Glacial Epoch ('Island Life,' p. 114), he says:—

"The evidence that such was the case" (alternate warm and cold periods) "is very remarkable. The 'Till,' as we have seen, could only have been formed when the country was entirely buried under a large ice-sheet of enormous thickness, and when it must therefore have been, in all the parts so covered, almost entirely destitute of animal and vegetable life. But in several places in Scotland fine layers of sand and gravel, with beds of peaty matter, have been found resting on 'till' and again covered by 'till.' Sometimes these intercalated beds are very thin, but in other cases they are twenty or thirty feet thick, and in them have been found remains of the extinct ox, the Irish elk, the horse, reindeer and mammoth. Here we have evidence of two distinct periods of intense cold, and an intervening milder period sufficiently prolonged for the country

to become covered with vegetation and stocked with animal life."

Let us now see to what all this leads. It has been proved beyond the possibility of a doubt that, at the time the till was being formed which *overlies* the Scottish interglacial beds, the whole of Scotland, Scandinavia, the bed of the North Sea, and a great part of the north of England was covered with one continuous sheet of ice upwards of 2000 feet in thickness. This sheet overwhelmed the Hebrides, the Orkney and Shetland islands, extended into Russia, filled the basin of the Baltic, overflowed Denmark and Holstein, and advanced into North Germany as far at least as Berlin. It has also been demonstrated that, at the time the Lower Till was being formed which *underlies* these interglacial beds, northwestern Europe was under a still more severe state of glaciation. The ice-sheet at this time advanced farther south into England, and extended into North Germany as far as Saxony. It is perfectly obvious that this sheet must have destroyed all plant and animal life in Scotland; and before the country could have become covered with vegetation and stocked with those interglacial animals, to which Mr. Wallace refers, the ice must have disappeared and the climate become mild.

Equally conclusive are the facts adduced by Mr. Wallace in reference to the interglacial beds of England. "In the east of England, Mr. Skertchly," he says, "enumerates four distinct bowlder clays with intervening deposits of gravels and sands. Mr. Searles V. Wood, Jr., classes the most recent (Hessle) bowlder-clay as 'post-glacial,' but he admits an intervening warmer period, characterized by southern forms of mollusca and insects, after which glacial conditions again prevailed with northern types of mollusca. Elsewhere Mr. Wood says: 'Looking at the presence of such fluviatile mollusca as *Cyrena fluminalis* and *Unio littoralis* and of such mammalia as the hippopotamus and other great pachyderms, and of such a littoral Lusitanian fauna as that of the Selsea bed, where it is mixed up with the remains of some of those pachyderms, as well as of some other features, it has seemed to me that the climate of the earlier part of the Post-glacial Period in England was possibly even warmer than our present climate; and that it was succeeded by a refrigeration sufficiently severe to cause ice to form all round our coasts, and glaciers to accumulate in the valleys of the mountain districts.'" That these faunæ indicate a warm and equable condition of climate is further evident from Mr. Wallace's remarks: "The fact," he says, "of the hippopotamus having lived at 54° north latitude in England, quite close to the time of the Glacial Epoch, is absolutely inconsistent with a mere gradual amelioration of climate

from that time to the present day. The immense quantity of vegetable food which this creature requires, implies a mild and uniform climate with hardly any severe winter; and no theory that has yet been suggested renders this possible except that of alternate cold and warm periods during the Glacial Epoch itself. . . . . Thus the very existence of the hippopotamus in Yorkshire as well as in the south of England in close association with glacial conditions must be held to be a strong corroborative argument in favor of the reality of an interglacial warm period."

I trust that Mr. Wallace has not been misled by Mr. Wood's unfortunate use of the term "Post-glacial" as applied to the Hessle bowlder-clay. The Hessle bowlder-clay as surely belongs to the Glacial Period proper as does the true Till of Scotland, which covers the lowlands and overlies the interglacial beds of that country. It is the *moraine profonde* of the last *mer de glace* which covered the greater part of northwestern Europe. The Upper Till of Scotland and the Hessle bowlder-clay of England belong to the same period. This has been clearly shown by Professor J. Geikie in his 'Great Ice-Age,' chapter xxx (2d edition), and in 'Prehistoric Europe,' chapter xii, and elsewhere. The Hessle bowlder-clay is, in short, a continuation of the Upper Till of Scotland.

The position of these Hessle beds to which Mr. Wallace refers, like that of the interglacial beds of Scotland, is between two bowlder-clays—the Hessle and the Purple bowlder-clays, both of which indicate a period of extreme glaciation; only the Purple bowlder-clay period was somewhat the more severe of the two. At both periods the greater part of northwestern Europe was buried under ice. We know that during the last great ice-period, which was undoubtedly the period of the Hessle bowlder-clay, the ice-sheet reached in North Germany as far as Berlin; while during the period of the Purple bowlder-clay it advanced to about Saxony.

The observations of Professor Torrell, Dr. A. Penck, Professor Credner, Professor Berendt, Dr. Jentzsch, A. Helland, F. Wohnschaffe, H. Habenicht, and other geologists have shown that there are in North Germany three distinct bowlder-clays—an Upper, Middle, and Lower, with two series of interglacial beds. In these interglacial beds have been found organic remains which evidently indicate a mild and genial condition of climate. The younger interglacial period (the one prior to the last great extension of the ice) in all probability corresponds to the last interglacial period of Scotland, England and Ireland. Interglacial beds belonging to the same period have been found in Switzerland, Italy, Denmark, North America, and other places, all indicating a mild and equable condition of climate.

There is another class of facts, almost entirely overlooked, which prove even more conclusively the warm character of interglacial periods. These facts will, however, be more appropriately discussed when we come to consider the question of warm polar climates.

It would be impossible within the limits of the present paper to give even the briefest outline of the recent discoveries in regard to interglacial periods. But though this were possible it would be wholly unnecessary, as the facts which have already been adduced by Mr. Wallace himself are perfectly sufficient for our present purpose.

If now it be true, as it undoubtedly is, that the Hessle bowlder-clay of England belongs to the same age as the Upper Till of Scotland, and that the last warm interglacial period, when the *Cyrena fluminalis* and *Unio littoralis*, the hippopotamus, the *Elephas antiquus*, and other animals of a southern type lived in England, occurred between two glacial periods so severe as to envelop the greater part of northwestern Europe in a continuous sheet of ice, then this particular interglacial period must have intervened during a high state of eccentricity, and not, as Mr. Wallace assumes, at a period subsequent to the Glacial Epoch proper, when the eccentricity had greatly diminished. This is obvious; for if the last great ice-sheet could have been produced without a high state of eccentricity, then there seems no reason why the one preceding it should not also have been produced without high eccentricity. If so, then all the previous ice-sheets may in like manner have been so produced. For the difference in magnitude between the last and penultimate ice-sheets was not so great as to warrant the supposition of any considerable difference in the amount of eccentricity at the two periods when these ice-sheets were respectively developed. In short, if the last great ice-sheet can be explained without the supposition of a high state of eccentricity, then there does not appear to be any real necessity for any theory of eccentricity in accounting for the Glacial Epoch.

If we adopt the Physical theory of the cause of the Glacial Epoch, we are compelled to maintain that the last two great Ice-periods were the indirect results of a high state of eccentricity, and in this case we can hardly avoid the conclusion that the mild intervening period was due to the same cause. The occurrence of a mild interglacial period between the two ice-periods is directly in opposition to Mr. Wallace's view that during a high state of eccentricity the ice would not disappear but be continued. It is in perfect harmony, however, with that which I advocate; for during high eccentricity a mild and equable condition of climate, when the winters occur in

perihelion, is as much a necessary result as a cold and glacial condition when they occur in aphelion.

The facts of Geology thus to me appear so far to be as much opposed to Mr. Wallace's modifications as are the principles of Physics.

Difficulty in detecting the Climatic Character of the earlier Interglacial Periods.—It follows according to theory that, other things being equal, the greater the amount of eccentricity the more equable and mild will the interglacial periods be. It is probable therefore that some of the earlier interglacial periods were milder and more equable than the last. It may be difficult in the present state of our knowledge to prove this conclusion by direct geological and paleontological evidence; but, on the other hand, it is certainly impossible to disprove it by that means. The absence of deposits containing organic remains indicative of a superior mildness of climate having obtained during early interglacial periods cannot certainly be regarded as satisfactory evidence against the conclusion just referred to. When we consider the enormous pressure and destructive power of an ice-sheet some 2000 or 3000 feet in thickness grinding down the face of a country, our surprise is that so much evidence remains of even the last interglacial period That so few relics of the flora and fauna of preceding interglacial periods have been preserved is a conclusion which we might *à priori* anticipate. This fact has been clearly pointed out by Mr. Wallace himself, who says:—"If there have been, not two only, but a series of such alternations of climate, we could not possibly expect to find more than the most slender indications of them, because each succeeding ice-sheet would necessarily grind down or otherwise destroy much of the superficial deposits left by its predecessors, while the torrents that must always have accompanied the melting of these huge masses of ice would wash away even such fragments as might have escaped the ice itself" (p. 118).

When we pass beyond the limits reached by the ice-sheets of the Glacial Epoch we may expect, of course, to find the remains of many of the plants and animals which lived during the earlier interglacial periods. But here, again, we encounter another difficulty; for we have in this case seldom any means of determining the age to which these remains belong. Unless in relation to overlying and underlying bowlder-clays, there seems in many cases no way of knowing to what interglacial period they ought to be assigned; or, in fact, whether they are really interglacial or not. If the remains in question indicated a condition of climate much milder than the present, the probability is that they would be classified as preglacial. I fully agree with Prof. J. Geikie, that many of those plants

and animals of a southern type which have been regarded as Preglacial are in reality of Interglacial age.

Objection as to the number of Interglacial Periods.—It has been urged as an objection to the Physical theory of the Glacial Epoch, that according to it there ought to have been more interglacial periods than we have direct evidence of having actually occurred. I am doubtful as to the force of this objection. I do not think that there could have been more than about five well-marked interglacial periods during the entire Glacial Epoch; three probably during the former half of the epoch, and certainly not more than two during the latter half. There would be a large interval between the two maxima of eccentricity of 100,000 and 200,000 years ago, when the alternations of climate would be comparatively moderate in extent. Besides it is not correct to assume, as is generally done, that the interval between two consecutive interglacial periods is only 21,000 years; for the mean rate of motion of the perihelion during the Glacial Epoch was considerably less than has been assumed. It will be seen from the table of the Longitude of the Perihelion, given in 'Climate and Time,' p. 320, that it has taken the perihelion 231,000 years to make one complete revolution.

If, therefore we assume, what of course is not certain, that mean rate of precession during the Glacial Epoch to have been the same as the present, then the rate of precession to that of the perihelion's motion would, in this case, be as 9 to 1. The equinoxial point will take 25,811 years to make one revolution; but as the perihelion moves in the opposite direction, it will reduce the time taken by the point in passing from perihelion round to perihelion to 23,230 years, which will represent the mean interval between two consecutive interglacial periods. But as the motion of the perihelion was very irregular, the length of the interval between the periods would of course differ considerably.

When we consider how difficult it must be to detect in teh drift covering glaciated countries even a relic of early interglacial deposits, and when moreover we remember that it is only within the past few years that geologists have begun to bestow any attention on the subject, it is certainly not surprising that direct geological evidence of so few interglacial periods has as yet been discovered. In England, geologists have, however, already detected evidence of three interglacial periods with four or five ice-periods. In Germany, quite recently, two interglacial periods and three or more ice-periods have been recognized by competent observers. In Denmark there are four bowlder-clays separated by intercalated beds of sand and clay. In severely glaciated Scotland, where traces of former interglacial

periods can hardly be expected, there have nevertheless been found in old preglacial buried channels and other sheltered hollows three, four, and in some places five, bowlder-clays, separated from one another by immense beds of sand, gravel and clay. Some of these beds are found to be continuous for long distances. It is true that these intercalated beds have yielded few or no organic remains, but it may well be that further research will yet result in the discovery of more abundant fossils; for frequently the beds in question are too thick and too extensive to allow us to infer their subglacial origin. They do not in such respects resemble the deposits which have been accumulated by aqueous action under ice, but have all the characteristics of deposits which have been laid down in lakes and lacustrine hollows. As some have already yielded organic remains, a more extended scrutiny will probably lead to the discovery of similar fossils in those beds which are at present believed to be unfossiliferous.

Interglacial Periods less strongly marked in Temperate Regions than Glacial.—I quite agree with Mr. Wallace that the interglacial deposits never exhibit any indication of a climate whose warmth corresponded to the severity of the preceding cold. This, however, cannot be urged as an objection, for it is a result which follows as a necessary consequence from theory. It theoretically follows that the cold of the glacial periods will not only exceed in severity the heat of the interglacial, but will also be of longer duration. During the glacial periods extreme cold is the characteristic of the winters, which, owing to the presence of snow and ice, only becomes moderated, although, of course considerably, during the summers. But, on the other hand, during interglacial periods mildness and equability of temperature rather than heat are the characteristics both of summer and winter.

That the cold of the glacial periods must have continued longer than the warmth of the interglacial will, I think, be apparent from the following considerations. As long as a country remains permanently covered with snow and ice, the climate, as has been repeatedly shown, must continue cold, no matter what the direct heat of the sun may be. Astronomically considered the interglacial periods are, of course, of the same length as the glacial,—the mean length of which, during the Glacial Epoch, was about 11,600 years; but the cold of a glacial period would not, as we shall presently see, actually terminate at the end of the period, but would be continued on probably for centuries into the succeeding interglacial period. Suppose that during a glacial period the country is covered with a sheet of ice, which during the continuance of the period had accumulated to the thickness of 2000 or 3000 feet. All this enormous quantity of

ice would have to be melted off the ground before the warmth of the interglacial period would commence. So long as a single inch of ice covered the surface of the country, the cold would continue. Ice, as we have seen, by chilling the air induces fresh snow to fall; and of course it is only when the amount of ice annually melted exceeds that being formed from the falling snow, that a diminution in the thickness of the sheet would begin to take place. A real melting of the ice, and consequent decrease in the thickness of the sheet, would probably not commence till the astronomical and physical agencies in operation during the glacial period began to act in an opposite direction. In short, it would be the favorable conditions of the interglacial period that would effectually remove the ice; and it would be then, and only then, that the warmth would begin. While, again, at the close of the period, when the first inch of ice made its appearance on the surface of the country, the interglacial condition of climate would come to an end. The time required to remove the ice does not prevent an interglacial condition of climate; it only somewhat shortens its duration.

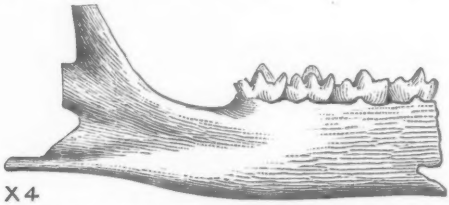
There is another circumstance worthy of notice here. It is this: as the mild and equable character of the climate during interglacial periods resulted to a large extent from the enormous transference of equatorial heat, and its distribution over temperate and polar regions, the difference of climatic conditions between the subtropical and the temperate and polar regions would be less marked than at present; in other words, the temperature would not differ so much with latitude as it does at present. This, as we have seen, is a conclusion which is fully borne out by geological and paleontological facts.

The question as to the probable cause of warm polar climates will next be considered.

ART. LI.—*A new Marsupial from the Miocene of Colorado;* by W. B. SCOTT.

ALTHOUGH there can be no reason to doubt that Marsupial animals of the opossum type existed in North America during Miocene times no remains of them, so far as I am aware, have hitherto been found. The Princeton expedition of 1882 obtained from the Miocene deposits of Chalk Bluffs, Colorado, a portion of a very small lower jaw containing four molar teeth, which on examination proves to have belonged to a small opossum not generically different from *Didelphys virginiana*, but very obviously distinct from that species.

This species may be called *Didelphys pygmæa*, and is defined as follows. Opossum very small, intermediate in size between *D. murina* and *D. elegans* of South America. Lower margin of the jaw nearly straight, and the ramus beneath the molar teeth of nearly uniform depth; coronoid process very weak, condyle marked off on a distinct neck; inflected angle of jaw projecting considerably behind the condyle. Molar teeth constructed on the ordinary opossum type, antero-internal cusps of penultimate molar very small, and heel of last molar consisting of two cusps instead of three, as in *D. virginiana*.



Left ramus mandibuli of *D. pygmæa*, seen from the inner side; 4 times the natural size.

This little animal was doubtless an insectivorous opossum, some three or four inches long, and finds its nearest living representatives in the small insect-eating opossums of South America. It would be interesting to make an extended comparison with some of the latter, but as yet I have had no opportunity to do this. Such opossums probably abounded in the sub-tropical Miocene forests of our western territories, in spite of the fact that they are extremely rare as fossils. This rarity can readily be understood when we remember their minute size and probably arboreal habits. The homogeneous and fine-grained matrix of Chalk Bluffs is well adapted to the preservation of such forms, and it is therefore no matter of sur-

prise that a far larger number of very small mammals should be found there than in the coarser matrix of the White River district in Dakota.

Morphologically this new species is of very small value, as it throws no important light upon questions of descent. But as a contribution to geographical zoology it is of great interest. It demonstrates the fact that the small insectivorous opossums, now characteristic of South America, existed in Miocene times in North America, and is additional evidence that the latter continent is the source from which the former received the greater part of its animal population, just as the great Palearctic continent seems to have been the original source of the modern faunas of the Ethiopian and Oriental regions. Thus, the tapir, the llama tribe, many edentates, the peccaries, and in all probability the monkeys and cats, have been traced to their origin in North America. The small opossum just described gives another characteristic feature of the South American fauna; and I may add that a small lizard from Chalk Bluffs, now in the Princeton Museum and as yet undescribed, points in the same direction.

There is thus every reason to believe that future discoveries will supply the missing terms and that it will be seen that the Tertiary fauna of North America was the starting point for the recent fauna of South America, just as migrations from Greece in Pliocene times gave rise to the characteristic mammalian population of modern Africa.

MEASUREMENTS.

Length of molar series	$0{\cdot}007^{m}$
" 1st molar	0·0015
" 2d "	0·002
" 3d "	0·002
" 4th "	0·0015
Height of 4th molar	0·002
Depth of ramus beneath 1st molar	0·0035
Depth of ramus beneath 4th molar	0·004

For the accompanying sketch, as well as for the exceedingly delicate and difficult work of preparing and mounting this minute specimen, I am indebted to Curator F. C. Hill.

Princeton, N. J., May 5, 1884.

ART. LII.—*On a method of obtaining autographic records of the free vibrations of a tuning-fork, and on the autographic recording of beats;* by ALFRED G. COMPTON.

THE exact determination of the rate of vibration of a tuning-fork by means of the siren has heretofore been attended with errors resulting from imperfections of the recording gear, and difficulty of maintaining and counting the beats of the two tones. I have sought to remove these errors by obtaining autographic records of the rate of the siren and of the difference between this rate and that of the fork. The experimenter, while obtaining these records, being freed from the necessity of even counting the beats, no personal element enters into the observation, and the records being permanent, can be studied at leisure. The following is the method of obtaining the autographic records.

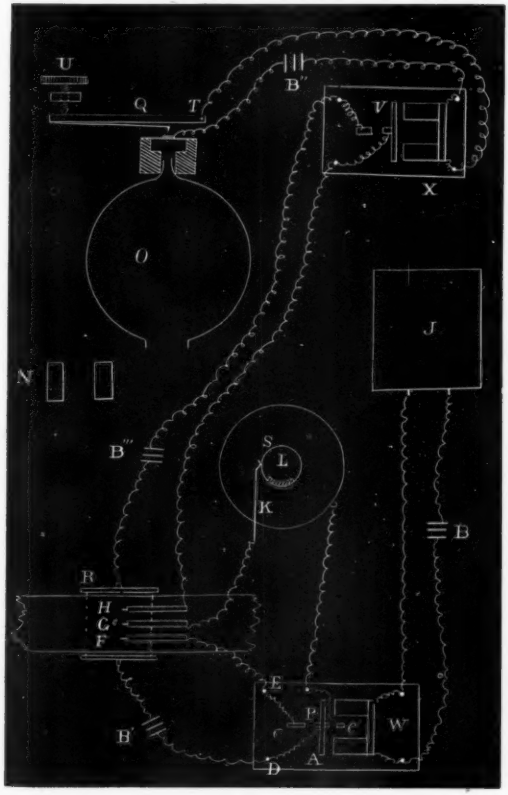
A strip of chemically prepared paper, which rests on a metal wheel, being drawn by clock-work under three platinum pens placed in electric circuits, three simultaneous electro-chemical records are received. One of these is a line of dots made at the rate of one a second, by a chronometer placed in the circuit of the same battery with one of the pens. The second is a row of dots made by the closing of the same circuit by a siren once in each revolution, while singing nearly in unison with the fork. The third is a row of dots made by the closing of the circuit of a second battery, once for each beat of the fork and the siren.

It thus results that from the same strip of paper can be counted the number of revolutions made by the siren in any number of seconds (from which the number of impulses produced by the siren results), and the number of beats in the same time,—which is the difference between the number of shocks imparted to the air by the siren and the number imparted by the fork. The record being made without throwing any work upon the fork, the rate of vibration of the unconstrained fork results.

The following description will give an idea of the details of the method.

A break-circuit chronometer J and a relay W are included in the circuit of a battery B of one carbon cell. The armature A is therefore freed from the magnet once a second by the break-circuit mechanism of the chronometer. When the armature is thus freed, a platinum point P closes the circuit of another battery B′, the current of which then passes through the armature A, the platinum contact point *c*, the pen F, the metallic wheel R on which the pen point rests, and so back to

the battery. When the circuit of battery B is closed, the relay-armature makes contact at C′. From C′ a wire passes to the framework of a De la Tour's siren S. Attached to the frame of the siren is an insulated support carrying a platinum spring K, which bears against an ebonite drum on the axis of the siren, and touches at each revolution a strip of metal embedded in the drum, and in electrical communication with the axis. From the spring, a wire passes to the platinum pen G.



It follows that, when the armature is in contact with C′, which is about $\frac{99}{100}$ of each second, the current of the battery B′ flows through the post D, the armature A, the contact point C′ and the siren S to the pen G, and so to the battery. A clock-work gives motion to a fillet of paper moistened with a solution of iodide of potassium, drawing it between the pens and the

roller R. When the siren is revolving, the current of B′ passes through the pen F at each beat of the chronometer, and through the pen G at each revolution of the siren, unless, at the moment of closing the siren-circuit at S, the same circuit is opened through the absence of the platinum point P from the contact point C′. There are thus two rows of dots, side by side on the paper, which give the number of revolutions of the siren and the time.

The object sought in making the records at the two pens, F and G by the current of the same battery is to secure the suppression of one of the siren dots, whenever it coincides exactly with one of the seconds dots. If this adjustment is perfect, the interval of time between two missing dots in the siren record is a whole number of seconds in which an exact whole number of revolutions of the siren has been made; otherwise the number of revolutions made is a whole number plus a fraction of uncertain value. The method of making this adjustment, and the conditions on which its accuracy depends, will be discussed below.

Between the siren tube and the bellows is placed one of Cavaillé Col's pressure-regulators. With this and a proper adjustment of the weight on the bellows, it is easy to keep the pitch of the siren so constant that it shall give with the tone of a fork any desired number of beats a second, for thirty or forty seconds, with scarcely any perceptible change of rate. To cause these beats to record themselves, the following arrangement is used.

The fork N is mounted before the mouth of a Helmholtz resonator O, which is nearly or exactly in unison with it. To the small opening of the resonator is fitted a cylindrical drum, of which the farther end is closed by a membrane to which is glued a small disk of platinum foil. A lever Q, whose fulcrum is at T, is moved by a fine screw U, so that a platinum point carried by the lever may be made to nearly or quite touch the platinum disk. The platinum disk is connected, by fine wire, with one pole of the battery B″, the current of which flows through the relay X, the lever Q, and the platinum disk, as long as the latter touches the platinum point. Whenever the membrane recedes from the platinum point, the circuit B″ is broken; the armature V then closes the circuit of the battery B‴ and a record is made by the pen H on the paper.

If now the siren and the fork be singing nearly in unison, beats will be heard; the two sets of vibrations being imparted to the membrane, its vibrations are intermittent. The contact between the point and the disk being so adjusted that the circuit B″ is broken once at every beat, the beats record themselves on the fillet as a row of dashes side by side with the other two records.

The contact of a rigid platinum point being found to interfere too much with the motion of the membrane, the point was attached to one end of a light spring about 115^{mm} long, the other end of which is soldered to the lever Q. The spring is made by flattening a piece of copper wire. It lies close to the lever and has very little play, but answers its purpose perfectly.

It may be thought that the relay X might be dispensed with, the battery B″ being made to record directly through the pen H. By the use of the relay, however, the dash made by the pen H at each beat, can be reduced to any convenient length; and besides, the distinct clicks of the relay at the beats, are much easier to observe than the beats themselves, particularly when these are not more frequent than two or three to the second. The variations in the rate of these clicks give clear indications of changes in the rate of the siren, and their cessation shows when the excursions of the membrane are too small to cause a record of the beats.

In the management of the apparatus, it is obviously not necessary that the motion of the fillet of paper should be uniform. Care has to be taken, however, that it shall not at any time be retarded very much, as the siren dots then become too crowded, and cannot be counted. Considerable inequality of the pressure of the pens on the paper will cause the fillet to run off to one side. This is prevented by placing the three pens as near together and as near the middle of the fillet as possible, equalizing the pressure on them, providing the sides of the roller with flanges, and placing guides for the fillet just in front of the roller. Of course the roller and all the contact points must be kept clean.

Care must be taken that the armature A, while very close to the poles of the magnet, shall not touch them, otherwise the residual magnetism will retard its release. I find it most convenient to place the plane of the mouth of the resonator nearly parallel to the plane in which the fork vibrates, as the resonator is then not in the way of the bow. The best effect of the fork in producing beating vibrations of the membrane occurs, however, when the opening of the fork is not exactly in front of that of the resonator, but at a distance to one side, which depends on the distance of the siren. The best position is found by sounding the siren and the fork, and moving the stand carrying the resonator, till the relay X is heard ticking in unison with the beats. As finally placed in the experiments which gave the best results, the center of the siren was 80^{mm} in front of the plane of the mouth of the resonator and 50^{mm} to the right of the center of the mouth, while the center of the fork was 20^{mm} in front of the plane of the mouth, and 50^{mm} to the left of it.

To adjust the contact point of the membrane, the set-screw is turned forward while the siren is sounding, but the fork silent, till the click of the relay X reports the circuit closed. If now the screw is turned gradually back, the relay will begin to rattle or chatter. The best position is that in which the chattering is just about to begin. If the fork be now sounded by a stroke of the bow, the circuit will be broken, showing that the membrane moves *inward towards* the vibrating fork, affording thus an interesting illustration of the well-known law that atmospheric pressure is diminished in the neighborhood of a vibrating body. As the tone of the fork dies out, the membrane gradually returns, continuing its vibrations, and while returning, it will at every beat close the circuit and produce a dash on the paper. If the fork be too near the mouth of the resonator, the strokes of the beating relay will not begin till some time after the stroke of the bow, when the vibrations of the fork have nearly died out; if it is too far away, they will begin immediately, but will not last long. The dashes will sometimes be seen to consist of a row of dots, showing that the circuit has been broken several times, not merely by the maximum inward vibration of the membrane, but by several preceding and following it. But generally, these dots flow together, and only appear as a dash. In the accompanying specimen records, the dashes have a length equal to that of about three siren-revolutions or thirty vibrations.

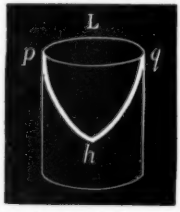
For membranes, I have used thin sheet rubber, paper, goldbeater's skin, thick vulcanized rubber (about 2^{mm}), and leather. The best results have been obtained with white kid such as is used in the making of organ bellows. The membrane with which the best records have been obtained is of this material, is 28^{mm} in diameter, and carries a platinum disk about 4^{mm} square and $0{\cdot}1^{mm}$ thick. The connecting wire (No. 28), is carried across the membrane to the edge, where it is securely fastened to the support. If left loose, it produces by its accidental vibrations, a constant chattering of the recording relay. To steady the membrane a little, I have sometimes found it advantageous to give it a slight tension and outward convexity by means of a thread wound round a small wrest-pin.

The exactness of the coincidence between seconds and siren revolutions indicated by the missing siren dots in the record, depends on the following considerations.

If we denote the duration of an excursion of the armature of the relay W by a, and the duration of the siren contact at S by b, we shall have if $a > b$, $a - b =$ the excess of the duration of the break in the siren-circuit at A over the duration of the siren contact at S. If the whole siren contact is coincident with any portion of the break a, the siren-record will be

elided; this elision will happen, therefore, if the beginning of the break precedes or follows the beginning of the contact by the amount $a-b$; and the fact of the elision of a record will indicate that the second and siren records coincide to within $\pm(a-b)$. The possible error therefore in the counting of the number of siren revolutions in the interval between two coincidences amounts to $2(a-b)$, and is 0 when $a=b$. If, however, the chemical record does not begin till a time t' after the contact is closed and continues for a time t'' after it is broken, then making $t=t'\backsim t''$, what may be called the "effective" or "chemical" contact will have the duration $b\pm t$, and the error may amount to $2(a-b\pm t)$. The quantity t may be due to either the delay in the starting or the stopping of the chemical action after the circuit has been made or broken, or to the dragging of the color under the point of the pen when the paper is too wet. The former appears from experiments to be inappreciable, the latter becomes large and uncertain if the paper is too wet, but is apparently insignificant when care is taken to have the paper only just wet enough to let the current pass. If $a<b$, the siren-record will never be completely elided, but it may be shortened at either end or cut into two. It may be thus so much shortened as to appear to be elided, and so occasion an apparent coincidence when there is none in reality. This is therefore an additional reason for making b at least equal to a.

For the purpose of easily bringing about the equality of a and b the siren-contact was arranged as follows. The strip of metal embedded in the ebonite drum L on the axis of the siren was of the form shown at *phq*, and the platinum spring which rested on the drum was movable up and down the drum by a set-screw. After adjusting the magnet and the spring of the relay W, so as to give the shortest possible excursion of the armature A, the duration of the siren contact was made equal to that of the excursion by moving the spring to the proper position. In effecting this equalization, the duration of the siren-cotnact was measured by drawing the paper very rapidly under the pen, while the siren was rotating, and measuring the length of the dashes and the distance between the middle points of two consecutive dashes. The ratio of the first to the second, gives the duration of the contact in terms of the duration of a revolution, which latter is known. The duration of the armature excursion is found by stopping the siren, setting it in such position that its circuit is closed, drawing a paper rapidly under the pen, and measuring the ratio of the short gaps in the now nearly continuous record, to the interval between the centers of two gaps, which latter is



one second. In this way, after several adjustments, the duration of the armature-excursion and that of the siren were made very nearly equal and each equal to about 0·009 second.

With this adjustment, the "frequency" of the fork as found by counting the number N of revolutions of the siren and the number n of beats in a number N′ of seconds, would be, if the siren was higher than the fork and if the number of holes in the siren was 10, $\frac{10N-n}{N'}$; and this determination would be exact, if the two coincidences were exact. As the error in the coincidences is $\pm(a-b\pm t)$ the possible error in the frequency of the fork would be, neglecting t, $2\left(\frac{a-b}{N'}\right)$; so that when a and b were nearly equal and N′, as was frequently the case, was as great as ten or twelve seconds, the method would seem to promise a high degree of precision.

The following table shows the results obtained with one of Koenig's vowel-sound forks (marked OU):

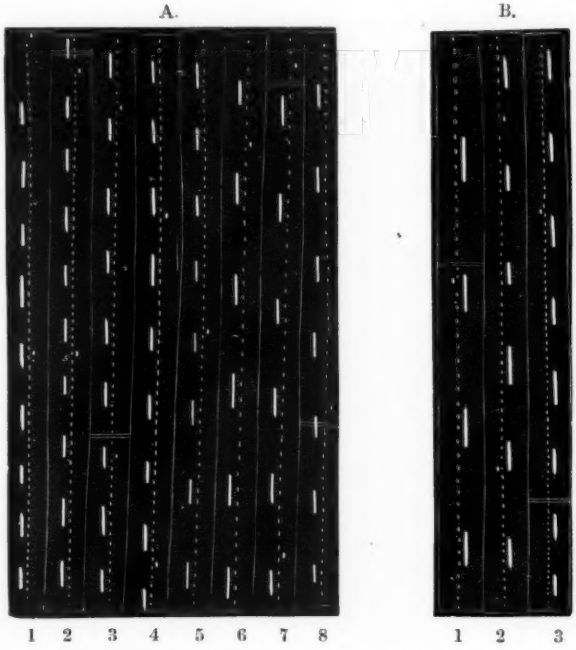
Exp.		Vibrations of siren.	No. of beats.	Vibrations of fork.	Time, seconds.	Vibrations per second.
1.	Oct. 8	1730	25	1705	5	341·0
2	" 8	3100	30	3070	9	341·1
3.	" 10	1040	16	1024	3	341·33
4.	" 11	3100	31·6	3068·4	9	340·93
5.	" 11	2770	43	2727	8	340·9
6.	" 11	1390	25	1365	4	341·25
7.	" 11	2060	15	2045	6	340·83
8.	" 11	4470	41·5	4428·5	13	340·66
9.	" 11	1040	16·7	1023·3	3	341·1
10.	" 12	2071	26·6	2044·4	6	340·73
11.	" 12	2400	11·5	2388·7	7	341·2
12.	" 12	3099	29·6	3069·4	9	341·04
						4092·07
				Mean,		341·01

The temperature during the experiments varied from 68° to 73° F. and the rate of beating from 1½ to 6 beats a second.

Nine selected experiments on October 20, 27 and 30, being experiments in which the coincidences were the most perfect and the records the clearest, gave the following results:

Exp.	Vibrations of siren.	Beats.	Vibrations of fork.	Time, seconds.	Vibrations per second.
1	3780	29·25	3750·75	11	340·98
2	1730	25·6	1704·4	5	340·88
3	3460	51·6	2408·4	10	340·84
4	2410	23·5	2386·5	7	340·93
5	1030	7·25	1022·75	3	340·92
6	1030	6·5	1023·5	3	341·17
7	4130	38·45	4091·55	12	340·96
8	2750	22·28	2727·72	8	340·96
9	5540	84·48	5455·52	16	340·97
T=73° F.			Mean,		340·96

The specimen records illustrate the character of the autograph. The record A is that of the experiments 2 and 3 of the second series. The dots in the middle row represent the siren revolution, the heavy dashes on one side of them the beats, and the light dots on the other side the seconds. It will be observed that the first two seconds of the record were useless for want of a coincidence. The first coincidence occurs at the mark ‖, a second one similarly marked occurs three seconds later, a third five seconds after the first, and a fourth at the end of ten

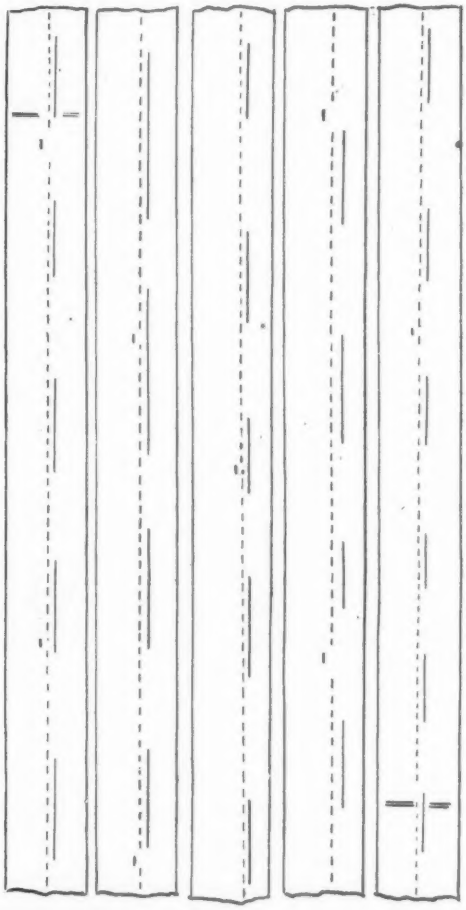


seconds. Experiment No. 2 of the table gives the results recorded in the interval between the third and eighth seconds, and experiment No. 3 is the result of the whole ten seconds. The "marginal remark" on the original record is "coincidences not quite perfect, but errors similar and equal."

The record B is a rejected observation of October 20. It will be seen that the first second's dot does not quite coincide with the siren record, though the nearest siren dash is partly effaced. If this were taken as a coincidence, the result would be $\frac{1384-14}{4}=341{\cdot}5$ showing how much the accuracy of the

method depends upon the exactness of the coincidence. It might be estimated that the first fraction of a revolution in this record is 0·8 in which case the result would be $\frac{1378-14}{4}=341$; but it is preferred to reject the result, particularly as the time, four seconds, is short.

C.



The records A and B having been rendered somewhat indistinct in the photographic reduction, the record C is added, and is reproduced without reduction or reversal. It shows the

exact coincidences at the first, fourth, sixth, seventh and ninth seconds, and the imperfect coincidences at the second, third and fifth. The rate of the fork as determined from it is

$$\frac{2750-22{\cdot}8}{8} = 340{\cdot}97$$

The above results are submitted as the first obtained by the proposed method. I believe that, with certain improvements in some of the mechanical details, a considerably higher degree of accuracy may be attained, and the method be made as exact as the optical methods, with the additional advantage of permanence.

ART. LIII.—*Notes on the Volcanic Rocks of the Great Basin;* by ARNOLD HAGUE and JOSEPH P. IDDINGS, of the U. S. Geological Survey.

BETWEEN the abrupt eastern wall of the Sierra Nevada and the western base of the Wahsatch Range lies the broad expanse of country, over 400 miles in width, known as the Great Basin.

It offers such sharply defined topographical and geological characteristics in such striking contrasts to the adjoining areas that it forms on the grandest scale one of the most marked physical features of the Cordillera. As the region in general presents such great uniformity of geological structure, and has everywhere been subjected to much the same physical conditions it has been called by both King and Powell the geological province of the Great Basin.

Across the broadest portion of this interior basin the Geological Exploration of the 40th parallel examined a belt of country nearly 100 miles wide, and the geologists attached to the expedition brought in large collections of volcanic rocks and gathered many data as to their mode of occurrence and geological relations, the results of which will be found in the published reports and maps of the exploration. In volume vi of these publications Professor Zirkel* presented the results of his investigation and determination of the crystalline rocks based upon an examination under the microscope of many hundred thin sections.

One result of this work has been to give a great impetus to the study of microscopic petrography both in this country and in England. Since the publication of Zirkel's work microscopic petrography has made rapid strides, new methods have been introduced and many errors pointed out. Perhaps the

* Microscopical Petrography, Washington, 1876.

most important advance made lies in the direction of more accurate methods for determining the species of feldspars.

Investigations in recent years have shown that many feldspars formerly regarded as sanidin really belong to one or more species of triclinic forms. This is noticeably the case with the rocks of Hungary and the volcanic islands of the Mediterranean, like Santorin. In consequence many lavas formerly determined as trachytes are now more properly referred to andesites. Again, since Zirkel's work a large number of new thin sections have been prepared from the rocks not heretofore examined in the collection of the Fortieth Parallel Exploration and considerable new material has been gathered from the many mining districts scattered throughout the Great Basin. The Washoe and Eureka districts, the two most important mining regions in Nevada, localities rich in the variety of their volcanic extrusions, have been studied with care and the results greatly increase our knowledge of the volcanic phenomena of the region.

For these reasons the writers of the present article have for some time been engaged in reviewing the Tertiary and Post-Tertiary igneous rocks of the Great Basin and hope before many months to submit their report for publication to the Director of the United States Geological Survey.

Zirkel classified the volcanic rocks of the region under the following heads: propylite, andesite, augite-andesite, dacite, trachyte, rhyolite and basalt, a classification adopted by the geologists of the Fortieth Parallel Exploration, they only differing from him in certain specific determinations.

Propylite.—Recently Mr. George F. Becker* in his work on the Washoe District made a thorough investigation of the so-called propylite and as a result denied the independence of the rock-species. His method of work and conclusions are given so fully that it is unnecessary to enter upon the subject here, except to say that we quite agree with him, so far as the non-existence of propylite as a distinct rock-species in the Great Basin is concerned.

Trachyte.—It will be readily admitted that in a classification of volcanic rocks based primarily upon the prevailing feldspar present it is a most serious error if the feldspars are wrongly determined. This is just the error that Zirkel was constantly committing in the work above quoted, and throughout his report he describes the feldspars in certain rocks as sanidin, when careful observations show in the light of the present day that they belong to one or more species of triclinic forms.

We find after long and searching investigation of the rocks from the Great Basin, so far at least as they have come under

* Geology of the Comstock Lode, Washington, 1882.

our observation, that there are none which can be classed as trachytes,—using the term, of course, in the strict sense in which it is now employed by most petrographers and probably by all who make use of the microscope in the determination of crystalline rocks. A trachyte is that variety of volcanic rock in which the predominating feldspar is orthoclase, but which is so low in silica as to be free from secretions of quartz if fully crystallized. This definition agrees with that of both Zirkel* and Rosenbusch,† "a Tertiary or Post-Tertiary quartzless orthoclase rock."

Now none of the rocks described as trachytes by Zirkel from the Great Basin contain any appreciable sanidin. They are all plagioclase rocks. Of the feldspars in the thin sections studied by Zirkel, nearly all show more or less striation. There occur many, however, in which the lamellæ do not traverse the entire crystal, reaching only a quarter or one half the way, and others in which only a single narrow stripe can be detected. It was formerly considered that any feldspar which did not show lines of striation was orthoclase, and so strongly had this idea intrenched itself in the mind, that those feldspars whose thin sections showed twinned lamellæ only at one end were thought possibly to be orthoclase containing lamellæ of a triclinic feldspar, as suggested by Zirkel.‡

The application of optical tests to the feldspars of these so-called trachytes and questionable rocks of the Great Basin leaves no doubt as to their true nature. Simple Carlsbad twins when cut so as to give symmetrical extinction angles or good cleavage, prove to be quite basic plagioclase; indeed a scarcity or even a total absence of polysynthetic lamellæ is rather characteristic of the smaller sized porphyritic feldspars, the striations of the larger ones being usually so well developed as to be noticed in the hand specimen upon careful search with a pocket lens.

Chemistry fully confirms these optical determinations. This is well shown in the analytical work of the late Dr. George W. Hawes upon the "trachyte" of Mt. Rose, Washoe, Nevada, the results of which are published in detail in Mr. Becker's§ recent report.

Similiar results have been obtained by us from the "trachyte" of the Wahsatch Range, from characteristic rock of Eureka, Nevada, and from the volcanoes of the Pacific Coast.‖

In these cases the feldspars were isolated by the Thoulet

* F. Zirkel, Mikroskopische Beschaffenheit, 1873, p. 290. F. Zirkel, Exploration of the Fortieth Parallel, vol. vi, 1876. p. 6.

† H. Rosenbusch, Mikroskopische Physiographie, 1877, vol. ii, p. 179.

‡ Mikroskopische Beschaffenheit, p. 134.

§ Geology of the Comstock Lode, p. 67.

‖ Notes on the Volcanoes of California, Oregon and Washington Territory, this Jour., Sept., 1883.

solution of the double iodide of mercury and potassium and were found upon analysis to be andesine or oligoclase. Again, in examining the feldspars in these so-called trachytes application was made of Dr. Szabó's method of determining feldspar in rocks by means of the color imparted to the flame of a Bunsen burner with most satisfactory results, the feldspars giving the reactions for andesine and oligoclase, and confirming the optical and chemical determinations.

The normal trachytes of Zirkel mainly resolve themselves into hornblende-mica-andesites; the augite-trachytes into hypersthene-augite-andesite, and most of those that remain should be classed as dacites, while a few fine-grained earthy rocks more properly belong to rhyolites.

Among the localities in the Great Basin which are frequently mentioned as affording fine exposures of trachyte is the Snake River Cañon, but the specimens which we have examined from near Shoshone Falls are clearly plagioclase rocks, although they possess many of the superficial aspects which formerly were regarded as characteristic of trachytes, or orthoclase rocks. In all probability the great sheets of acidic lava that underlie the basalts of the Snake Plains are andesitic.

Investigation having demonstrated the non-existence of propylite and trachyte in the Great Basin we classify all the volcanic rocks of the region under the following types, arranging them for the purposes of the present paper according to their basicity rather than according to their geological relations: basalt, pyroxene-andesite, hornblende andesite, hornblende-mica-andesite, dacite and rhyolite. Within the limits of the present article it is only designed to point out some of the more important mineralogical and structural features, leaving all questions of their mode of occurrence, order of succession and chemical relations till the final report.

Basalt.—These rocks may be divided into two general types: (*a*) the porphyritic, consisting of a glassy and microlitic or microcrystalline groundmass, bearing relatively large crystals of olivine, feldspar, and occasionally augite, a structure showing close relations to that of many andesites; (*b*) the granular (granular in the sense used by Rosenbusch,*) an aggregate of quite uniform grains composed of well-developed plagioclase and olivine crystals with ill-defined patches of augite and magnetite, and frequently with considerable glass base.

The porphyritic variety is the type most frequently observed in the collection of the Fortieth Parallel Exploration and is probably by far the most abundant in the Great Basin. It is well described by Zirkel in his report. It is not, however, always holocrystalline, often carrying considerable glass base.

* Neues Jahrbuch für Mineralogie, etc., 1882, Band 2.

In this variety of basalt there is great variation not only in the relation of groundmass to porphyritic crystals but also in the size of individual crystals. No sanidins could be detected. In some basalts the larger secretions are confined to olivine, in others to small feldspars, with olivine in minute grains, while augite only occurs occasionally among the larger crystals, and only in exceptional cases are all three minerals found associated together as porphyritic secretions.

Other varieties show less and less olivine, and with the gradual increase of silica and the coming in of more and more hypersthene, rocks occur intermediate between normal olivine basalts and those with the typical andesitic composition and structure. The granular variety of basalt occurs far less frequently than the porphyritic, but is well shown in the structure of the rock which forms the top of the lava plain at Shoshone Falls, and there is reason to believe is well developed on the great table-land of the Snake Plains.

Pyroxene-andesite.—For the purposes of the present paper this provisional designation may be used to include both hypersthene-andesite and hypersthene-augite-andesite, two varieties of andesitic rocks not always easily distinguished. Whether there are any extrusions in the Great Basin which should be classed as augite-andesite is a matter of some doubt, and presents a question which can only be answered by the investigation of similar rocks in various quarters of the globe, and by lithologists coming to some conclusion as to where the line should be drawn. It is quite certain that characteristic augite-andesites have not been observed in this region. There are no augite plagioclase rocks free from olivine found here which are not characterized by either hypersthene or hornblende. Under the head of augite-andesite, Zirkel has described a number of typical hypersthene-andesites. They are porphyritic rocks having a groundmass for the most part glassy with the "felt-like" structure formed of innumerable feldspar and pryoxene microlites and magnetite grains, through which are scattered microscopical crystals of plagioclase, hypersthene and augite. Occasionally the rock occurs holocrystalline.

Until recently hypersthene has only in very exceptional cases been recognized as an ingredient in andesitic rocks, and not till Mr. Whitman Cross* published his description of the rock from Buffalo Peaks, Colorado, was the variety hypersthene-andesite generally admitted by lithologists.† Since his publication the present writers‡ have shown not only the widespread occurrence of this rock for several hundred miles along

* Bulletin of the U. S. Geological Survey, No. 1, 1883.

† Niedzwiedzki described a hypersthene-andesite from St. Egidi in South-Steiermark in 1872. Tschermak's Mineralogische Mittheilungen, 1872, iv, p. 253.

‡ This Journal, Sept., 1883.

the line of Pacific Coast volcanoes, but that all the pyroxene-andesites examined by them from along this belt may be referred to hypersthene-andesite.

Over the wide area of the Great Basin hypersthene is found in nearly all varieties of volcanic rocks. Its microscopic characters are very constant and quite similar to those given for this mineral in the andesites of the volcanoes of California, Oregon and Washington Territory. It is of a light brown color in thin sections and with few exceptions strongly pleochroic, being green parallel to the *c* axis and yellowish-brown at right angles to it. The strong pleochroism, generally gray or yellow color between crossed nicols and the constant parallelism of its extinction with the direction of the *c* axis distinguish it from the accompanying augite. The hypersthene varies somewhat in the strength of its pleochroism, which, as shown by analysis, probably corresponds to a variation in its chemical composition. Its determination rests upon a microscopic study of the thin sections, together with optical investigations upon isolated crystals showing their orthorhombic character by always extinguishing light parallel to the vertical axis and presenting interference figures with their bisectrices normal to the pinacoidal planes. Chemical analysis upon carefully selected material abundantly confirms optical tests.

Attempts to separate hypersthene from hornblende and augite in a fine-grained rock by means of a solution of cadmium-boro-tungstate proved only partially successful. The mixed grains were easily divided into two parts, one containing all the hornblende and a little pyroxene, and the other made up of a mixture of hypersthene and augite. By repeated treatment with a solution of specific gravity 3·39, the latter residue was divided into two parts, one consisting almost wholly of hypersthene with a small amount of augite, and the other largely composed of augite but still carrying a trace of hypersthene. A careful examination under the microscope of the purest hypersthene product indicated that considerably less than one-tenth belonged to augite. An analysis by Mr. S. L. Penfield, of the Sheffield Scientific School, is given in column I. Assuming now that the relation existing between the hypersthene and augite is in the proportion of nine to one and calculating a possible composition for the two minerals, it is evident that the orthorhombic mineral carries more lime and alumina and less magnesia and iron than the hypersthene found in the pumice of Mount Shasta.* In columns II and III are given a calculated theoretical composition of the hypersthene and augite based upon Mr. Penfield's analysis of the mixture of the two minerals.

* This Journal, Sept., 1883.

	I Mixture.	II Hypersthene.	III Augite.
SiO_2	51·16	51·39	49·02
Al_2O_3	3·50	3·26	5·64
TiO_2	·73	·73	·73
FeO	15·46	16·45	6·45
MnO	·56	·56	·56
MgO	19·22	19·75	14·37
CaO	8·84	7·31	22·60
Ignition	·42	·42	·42
	99·89	99·87	99·79

Wherever the two minerals occur together, the hypersthene is seen to be of earlier crystallization than the augite, and, at the same time it undergoes decomposition much more readily, in this respect resembling olivine. When decomposition sets in a fibration starts from the surface and cracks in the crystals, and advances parallel to the vertical axis. Fibrous hornblende of light green color, or colorless in thin sections with low angle of extinction, is the ordinary alteration product, a change which is similar to the formation of uralite from augite, the minerals resulting from the two processes being indistinguishable from one another under the microscope. Hypersthene occurs in all the volcanic rocks of the Great Basin except typical olivine basalts and the most acidic rhyolites. It forms an essential ingredient in many of the hornblende-andesites, occurs sparingly in dacite and has been detected in some varieties of rhyolite, presenting almost as wide a range as augite.

Hypersthene occurs as an essential ingredient in the rocks from Washoe described as augite-andesite by Mr. George F. Becker in his recent work on the Comstock Lode.

Indeed it may be said that there is no pyroxene-andesite in the collection from this district in which hypersthene does not equal and in most cases surpass the augite in amount. It presents all stages of alteration from the fresh to the thoroughly decomposed mineral. In many thin sections the augite is perfectly fresh, accompanied by hypersthene wholly altered. It is this mingling of both hypersthene and augite in the rock which explains the otherwise strange occurrence of both fresh and wholly decomposed pyroxene in the same thin section mentioned by Mr. Becker, who in his examination of the augite-andesite failed to recognize the hypersthene. He frequently makes use of such expressions as "A portion of the augites are fresh, the remainder converted into chlorite,"* and "Some of the augites are almost unattacked and show thor-

* Geology of the Comstock Lode, p. 128.

oughly characteristic cleavages, extinctions, etc. Others are partially converted to chlorite, and yet others are wholly replaced by the uniaxial dichroitic green mineral." In the light of the present investigation it is now perfectly evident that the decomposed mineral is mainly referable to hypersthene.

The relationship already pointed out by us as existing between olivine and hypersthene in the rocks of the Pacific Coast volcanoes* holds equally good for the Great Basin, the olivine increasing and replacing the hypersthene as the rock becomes more and more basic.

Hornblende-andesite.—This rock forms a well characterized type of the volcanic rocks of the Great Basin, standing as an intermediate variety between the acidic and basic lavas, in general being more acidic than the pyroxene-andesites. Many of the rocks classed by Zirkel as simply andesites we would regard as pyroxene-andesite carrying a small amount of hornblende scattered through a groundmass of pyroxene and plagioclase, the hornblendes being too few in number to characterize the rock. Hypersthene and augite occur as the accessory minerals in the more basic varieties of hornblende-andesite, showing transitions into pyroxene-andesite, while, on the other hand, mica gradually comes in as the rock becomes more and more acidic.

Hornblende-mica-andesite.—Under this head may be classed a large number of andesitic extrusions scattered throughout the Great Basin from the Sierras to the Wahsatch in which mica occurs as a characteristic and essential ingredient. Indeed a large proportion of the rocks formerly regarded as trachytes properly fall under this division. In these rocks the feldspars have a decidedly vitreous appearance, while the texture of groundmass possesses a rough porous character presenting what is known as the "trachytic habit," but, as already shown, the entire absence of orthoclase among the porphyritic crystals prevents their being considered in any other light than as andesites. While, as already stated, sanidin is regarded by most lithologists as the prevailing feldspar found in trachytes, it should be remembered that von Richthofen recognized an "oligoclase-trachyte" in which sanidin was not even an essential ingredient; this rock agreeing with the hornblende-mica-andesites of the Great Basin.†

Dacite.—Following the development of the mica, quartz secretions begin to appear as the rock passes more and more into acidic varieties, and with the appearance of quartz, hornblende and pyroxene rapidly diminish. This gives a well-defined rock composed mainly of plagioclase, quartz and mica,

* This Journal, Sept., 1883.

† Natural System of Volcanic Rocks, San Francisco, 1867, p. 36.

with a varying amount of sanidin as an accessory ingredient. In the extent of its extrusions dacite is of less importance than either andesite or rhyolite, yet its occurrences are far more widespread than has been supposed, as many rocks heretofore regarded as acidic trachyte and rhyolite have upon investigation proved to be characterized by plagioclase instead of orthoclase. This is especially the case with many rocks of the Fortieth Parallel Exploration formerly classed as hyaline, pumiceous and glassy forms of rhyolite, but whose feldspars as shown by the microscope are unquestionably triclinic.

Rhyolite.—Notwithstanding the absence of trachyte, orthoclase rocks are by far the most abundant of all the acidic rocks of the Great Basin. Rhyolite extrusions occupy very large areas forming broad plateaus, high mountain peaks and innumerable minor outbreaks. In most localities between the Sierras and the Wahsatch, wherever volcanic activity has played an important part, rhyolite in one form or another has reached the surface. Although plagioclase crystals are well developed in varying proportions in a large number of rhyolites, orthoclase is in all cases the prevailing and characteristic feldspar. The rhyolites have been so well discussed and mapped in the reports of the Fortieth Parallel Exploration and their microscopical characters described in such great detail by Zirkel that very little need be said within the limits of this paper except to give their subdivision and to point out some of their relations to other rocks.

All the rhyolites of the Great Basin may be classified under one or the other of the following heads:

Nevadite,
Liparite,
Lithoidal Rhyolite,
Hyaline Rhyolite.

This sub-division agrees with that proposed by von Richthofen with the exception that he included both the lithoidal and hyaline varieties under one head. As many of the lithoidal rocks present a characteristic physical habit, as well as a thoroughly crystalline groundmass, it seems proper to separate them from the distinctly glassy forms, although varieties frequently occur which pass by insensible gradations from one to the other.

Nevadite.—This rock is characterized by an abundance of porphyritic crystals imbedded in a relatively small amount of groundmass. It bears a strong superficial resemblance to granite, produced, as von Richthofen says, "by the similarity of color, which is of light shades of gray and red, and by some affinity in mineral composition." This resemblance, however, does not hold in a strict lithological sense, as the nevadites

possess a porphyritic and not a granitic structure, the rock varying from a holocrystalline groundmass to one rich in glass and from a dense to a porous texture. Von Richthofen's use of the expression "nevadite or granitic rhyolite," has, it seems to us, misled lithologists to infer that he referred to the internal structural habit of nevadite, and that he regarded its structure as similar to granite. Professor Zirkel slightly modifies von Richthofen's definition of nevadite* and in his chapter on rhyolites says, "The scope of this section will be confined to a description of the proper felsitic or porphyritic rhyolites, for the almost granitic rhyolites (nevadites) are wanting in the examined territories."† From that time the signification of the term nevadite has gradually changed until it has come to designate a Tertiary volcanic rock having the "rein körnig" or granular structure of granite.‡ Now such a rock has never, as yet, been recognized in Nevada and its existence anywhere is at least highly problematical. Moreover it is evident that von Richthofen comprehended the glassy nature of the rocks called by him "nevadite" as he says, speaking of the larger crystals, that, "they are enclosed in a paste which is probably a partially microcrystalline, and partially amorphic aggregation of the same ingredients."

Liparite.—This rock in distinction from nevadite is characterized by a small number of porphyritic crystals imbedded in a relatively large amount of groundmass but like nevadite may occur in a holocrystalline condition as well as in a glassy one. Both nevadite and liparite possess the porphyritic structure, but both varieties are so characteristic of Nevada, with such distinct lithological features and rarely if ever occur together that it seems desirable to retain at least for the Great Basin the classification as first suggested by von Richthofen.§

Between rhyolite and dacite, as might be supposed, there exist many rocks upon which opinions might justly differ as to which class they should properly be referred. Such instances are, however, no more frequent than the transitions between basalt and hypersthene-andesite, between hornblende- and pyroxene-andesite, or any two closely allied species. Indeed, where the conditions for the developement of sanidin seem favorable it usually comes in strong force; the change from plagioclase to orthoclase being in many cases quite marked.

* Microscopical Petrography, p. 8. † Ibid, p. 8.

‡ H. Rosenbusch, Neues Jahrbuch für Mineralogie, 1882, vol. ii.

§ It seemed necessary to enter somewhat fully into an explanation as to the position of nevadite, partly because its exact relations to other volcanic lavas has, in our opinion, been misunderstood, and partly because in the paper on the "Volcanoes of California, Oregon, and Washington Territory" we pointed out that the rock from Lassens Peak mentioned by von Richthofen as a typical nevadite, was not an orthoclase rock, consequently not to be classed with the nevadites of the Great Basin which form such characteristic extrusions in the state of Nevada.

Again the distinction between dacite and rhyolite is somewhat sharply drawn by a large development of biotite in the dacites, whereas as soon as the sanidin makes its appearance as the predominant feldspar mica loses its prominence, and in most rhyolites of the Basin, although there exist a few marked exceptions, mica plays a very subordinate part.

It might seem natural to suppose that where the basic rocks are largely characterized by anorthite and labradorite, the intermediate rocks by andesine and oligoclase, and the acidic varieties by orthoclase, that the trachytes would be represented by at least some minor extrusions. Investigation, however, shows that the typical trachyte known to occur in other parts of the world has never been brought in from this region. Over this wide area with its great variety of volcanic rocks sanidin only makes its appearance after quartz has come in as an essential constituent among the porphyritic crystals. It may be laid down as a general law for the Great Basin that there is among the volcanic lavas no quartzless variety of orthoclase rocks.

In geological reports descriptive of volcanic areas we frequently meet with the statement that the rocks are made up of "andesites and trachytes" or "trachytes and rhyolites." It seems to us that in future such expressions should be more carefully considered, it having been shown that at least in the Great Basin such an association of lavas is unknown.

Our work leads us to believe that trachytes occupy a far more restricted position among volcanic rocks than has heretofore generally been supposed. The independence of rhyolite and trachyte from a geological point of view seems quite clear, for in regions of widespread volcanic activity it is far more frequently associated with andesitic than with trachytic eruptions.

ART. LIV.—*Transition from the Copper-bearing Series to the Potsdam;* by L. C. WOOSTER.

DURING the summer of 1883, some facts throwing light upon the relationship existing between these formations along the St. Croix River, Wisconsin, fell under my observation, and, though not new in kind,* they may be of interest to those who are endeavoring to find in the East a correlative of the Wisconsin Potsdam.

In northwestern Wisconsin the Potsdam sandstone has a total thickness, from the Laurentian granite below to the Lower Magnesian limestone above, of about one thousand feet. There are two horizons in which fossiliferous remains are especially

* See vols. i, and iii, Wisconsin Geological Reports.

abundant, viz: (1) the middle of the formation, and (2) the middle of the upper third.

At Osceola Mills, about four miles from the southernmost outcrop of the Copper-bearing or Keweenawan Series, the second of these two horizons is found at an elevation of about 100 feet above the level of St. Croix River, and presents a somewhat peculiar though characteristic fauna. Some of these layers are exceedingly porous and friable, and yet they contain casts of *Holopea Sweeti* and a Bellerophon in great abundance. Were it not for the Potsdam trilobites and brachiopods in these same layers, one might well imagine that he was gazing upon a *Trenton* sandstone. But, a few feet below these layers all evidence of life ceases and one looks in vain for a fossil down to the water's edge. While closely examining these lower layers at Osceola, I was greatly interested in the discovery of several pebbles in the sandstone evidently derived from the Keweenawan series at the northward. The sandstone here became variable in color and hardness, being on the whole darker and in certain places exceedingly compact, or as Capt. Knapp expressed it, baked. But no fusion or evidence of heat from steam-holes was present.

The government force engaged in building dams on the St. Croix under the supervision of Capt. Knapp had, the previous winter, dug into a most curious deposit on the Minnesota side of the river, about four miles north of Osceola and near the outlying outcrops of Copper-bearing rock. Under the guidance of Capt. Knapp, the locality was visited late one afternoon, and the "most curious deposit" was found to consist of "trap" conglomerate. The conglomerate composed a ridge which stretched to the westward from the river bank to the bordering ledge of sandstone one-fourth of a mile back. The river end of the ridge is about fifty feet in height and one hundred feet in breadth at its base. The component bowlders, bowlderets and pebbles of the conglomerate varied in size from those at the base of the exposure thirty inches in diameter to the finely comminuted material at the top where the rock might with propriety be called sandstone. All the bowlders were highly altered, so that Capt. Knapp could see little resemblance between them and the hard, resistant and apparently unchanging "trap" bowlders and ledges with which he was familiar. But after much search a bowlder was found near the base of the exposure with an *unchanged* center of "trap." The matrix of this conglomerate consisted of the same material as the imbedded bowlders. Here and there in all parts of the exposure this matrix contained fragments of linguloid shells, apparently *Lingulepis pinniformis*. Many cavities in the matrix and in the bowlders were lined with quartz crystals. Not the slightest evidence of

heat was discovered, all the alterations being evidently the work of infiltrating waters continued through countless ages.

Conclusions: 1. The material of this conglomerate, all being more or less rounded, and the shells, being without exception fragmental, must have been subjected to violent wave action along cliffs of Copper-bearing rock at this exposed point of the ancient (not to say Archæan) island. 2. There was some evidence to show that this fifty feet in depth of conglomerate not only graduates into sandstone above, but also on each side. Hence the ridge may mark the mouth of a primordial mountain torrent. 3. The age of the deposit seen must be late Potsdam since it graduates into sandstone of that age.

4. This conglomerate is not exceptional, since the Potsdam is conglomeritic along its shore margin in Wisconsin, and on the St. Lawrence River in New York (as seen by the writer). This conglomerate is well shown in the vicinity of Laurentian granite at Chippewa Falls and Eau Claire, Wisconsin, and near Oak Point eighteen miles above Ogdensburg, New York. Hence the Keweenawan or Copper-bearing rocks were subjected to the same erosive and denuding agency, whatever that may have been, which broke off and transported to the sea-shore portions of Laurentian and Huronian ledges. In Wisconsin, only the lower layers of the Potsdam may, at the present time, be seen in contact with the Laurentian and Huronian rocks, except around the islands of quartzite and quartz-porphyry in southeastern Wisconsin. Here the conglomerate is uniformly present and presents phenomena analogous to that just described on the St. Croix above Osceola. 5. The Keweenawan series is older than, unconformable with, and has supplied much of the material for, the Potsdam sandstone.

These conglomerates bordering the Laurentian, Huronian and Keweenawan areas must have supplied a large part of the bowlders of the drift deposits of the Northern States.

ART. LV.—*On the Expression of Electrical Resistance in Terms of a Velocity*; by FRANCIS E. NIPHER.*

IF a spherical shell of radius r be charged with Q units of electricity, the density of electrification being ρ, the force dF over any element ds of its surface will be $2\pi\rho^2 ds$. This force is directed radially outward, and is due to the action of the electrification Q on the quantity ρds upon the element.

If the radius r be diminished to r', the energy of the electrification will increase if Q remains constant, this increase

* From Trans. Acad. Science of St. Louis. Read March 17th, 1884.

in energy being due to work done on the sphere by some external source, causing the sphere to collapse. If the element ds sweeps through a distance dr, the stored energy will be

$$dE = dF\,dr \tag{1}$$

in which both dF and dr are essentially negative.

Substituting in (1) the above value of dF and remembering

that $$\rho = \frac{Q}{4\pi r^2}$$

and $$ds = r^2 d\omega,$$

where $d\omega$ is the solid angle subtended by the element ds, we

have $$dE = \frac{Q^2}{8\pi}\frac{dr}{r^2}\,d\omega,$$

or $$E' - E = \frac{Q^2}{8\pi}\iint\frac{dr}{r^2}\,d\omega,$$

where one integration is carried over the surface of the sphere, and the other is carried inward between the limits r and r'. Performing the integrations, we have

$$E' - E = \frac{Q^2}{2}\left(\frac{1}{r'} - \frac{1}{r}\right) \tag{2}$$

But $\frac{1}{2}\frac{Q^2}{r'}$ is the energy of a sphere of radius r', charged with Q units of electricity, and hence the potential of the sphere on itself between the limits r and r' is equal to the difference in its initial and final energy.

If the sphere were connected with the ground by a wire of resistance (R), the radius (r) might be changed in such a manner as to preserve the potential (V) constant. In this case a current of constant intensity would flow through the wire, and as $V = \frac{Q}{r}$ it is clear that r must change at a uniform rate, or

$$\frac{r - r'}{v} = t' - t \tag{3}$$

where $t' - t$ is the duration of the operation. Further,

$$V = \frac{Q}{r} = \frac{4\pi r^2 \rho}{r} = 4\pi r\rho$$

and $$\rho = \frac{V}{4\pi r};$$

hence $$dE = dF\,dr = 2\pi\,\rho^2\,ds\,dr = \frac{V^2}{8\pi}dr\,d\omega,$$

or $$E-E' = \frac{V^2}{8\pi}\int\int dr\, d\omega = \frac{V^2}{2}(r-r') \qquad (4)$$

This is the stored energy during the operation. But the energy of the electrification at first was $\frac{1}{2}rV^2$, and at the end is $\frac{1}{2}r'V^2$, so that there has nevertheless been a diminution of energy

of $$E-E' = \frac{V^2}{2}(r-r') \qquad (5)$$

It appears that, under conditions of our experiment, the sphere has less energy at the close of the experiment than at the beginning by a quantity $\frac{V^2}{2}(r-r')$, while the equal energy represented by the potential of the electrification on itself was added. The total energy lost by the shell was, therefore,

$$E = V^2(r-r') \qquad (6)$$

The current in the wire was, by Ohm's law,

$$C = \frac{dQ}{dt} = \frac{V}{R};$$

hence $$Q-Q' = \frac{V}{R}(t'-t),$$

and hence the energy of the current during the operation was

$$E = \frac{V^2}{R}(t'-t),$$

or by (3), $$E = \frac{V^2}{R}\frac{r-r'}{v} \qquad (7)$$

The expressions (6) and (7) must be equal to each other, and

hence $$Rv = 1, \quad \text{or} \quad R = \frac{1}{v},$$

where v is the constant velocity of each point in the surface of the shell during the operation. This problem is well known, and a solution of it is given in Mascart and Joubert's treatise. The above solution is new to the writer, and embraces some features of interest.

Art. LVI.—*Lateral Astronomical Refraction;* by J. M. Schaeberle.

In astronomical investigations where an extreme limit of precision is sought, systematic errors are frequently recognized, which, for want of any other apparent cause, are usually attributed either to irregular variations in the constants used (as for instance, a change in the clock rate, a variable coefficient of flexure), or to a change in the personal equation of the observer. The object of this paper is to point out one more source of error by which astronomical observations are always more or less affected, and to show how, in a simple manner, the error can, in general, be eliminated.

In the theory of astronomical refraction as given by Laplace, Bessel and others, each investigator assumes that the refraction always takes place in a vertical plane, and all refraction tables in use at the present time are constructed on this hypothesis, which therefore assumes that all layers of atmosphere of the same density, over any given locality, are parallel to the horizon. That such an assumption is frequently the cause of errors, by no means insensible, which can, at most observatories, be removed by computation, will now be shown.

Let us suppose that two observers at points A and B, on the same level and separated by the short distance D, observe at the same instant, equal temperatures, the barometric pressures however being p_1 and p_2. Now in order that the pressures over the two stations shall be the same, the observer at B must ascend through the distance Δh corresponding to a decrease in the pressure p_2 equal to p_2-p_1. A line drawn from A to the elevated station will then be the line of equal pressure, and the inclination of this line to the horizon will equal $\tan^{-1}\frac{\Delta h}{D}$ which, since this angle will always be small, can be placed equal to $\frac{\Delta h}{D}$.

As the differences between the refractions computed for inclined and for horizontal strata will always be very small, an error in the assumed law of refraction will have little or no effect on these differences; terms of the second order becoming sensible only at great zenith distances. The familiar expression

$$r = a \tan z$$

giving nearly the observed mean refractions, and nearly corresponding to the refractions that would be produced by a homogeneous atmosphere 5·12 miles high, having an index of refraction $m=1{\cdot}00028$, can for the present purpose be assumed to represent the observed mean refractions.

Let $\frac{\Delta h}{D}$ be the inclination of the plane of equal density to the horizon, and let ψ be the angle which a vertical plane, perpendicular to the line of intersection of the inclined and horizontal planes, makes with the meridian, reckoned from the south point toward the west through 360°; the angle ψ always being in that quadrant in which the pressure is greatest.

Now a ray of light from a star lying in the plane whose azimuth is ψ, and making with the normal to the horizontal plane the angle ζ, will make the angle $\zeta+\frac{\Delta h}{D}$ with a normal to the inclined plane. For a homogeneous atmosphere the refractions for the first and second cases would then be given by the equations

$$\sin z=\frac{m}{\sin \zeta} \quad \text{and} \quad \sin z'=\frac{m}{\sin\left(\zeta+\frac{\Delta h}{D}\right)}$$

$$r=\zeta-z \qquad r'=\zeta+\frac{\Delta h}{D}-z'$$

or $$r=a \tan z \qquad r'=q \tan\left(z-\frac{\Delta h}{D}\right) \text{ very nearly.}$$

The error in the computed refraction due to the inclination of the strata will therefore be

$$\Delta r=a\left(\tan z-\tan\left(z-\frac{\Delta h}{D}\right)\right)$$

which, if we neglect terms of the second order, can be written

$$\Delta r=a\,\frac{\Delta h}{D}\sec^2 z.$$

The refraction Δr will moreover be wholly in zenith distance, and all rays, lying in the vertical plane whose azimuth is Ψ, will be refracted in a vertical plane. If Ψ'' denotes the angle which any other vertical plane makes with the meridian, all rays of light in this plane will, after refraction, lie in a plane which is inclined to the horizon by the angle

$$90°-a\,\frac{\Delta h}{D}\sin(\Psi-\Psi'')$$

The vertical and lateral components of refraction due to the inclination will then be respectively

$$a\,\frac{\Delta h}{D}\sec^2 z\cos(\Psi'-\Psi'') \quad \text{and} \quad a\,\frac{\Delta h}{D}\cos z\sin(\Psi-\Psi'').$$

The second expression giving, for the zenith distance z, the angular distance of a star from the vertical circle in which it

actually lies, while the first expression gives the displacement in zenith distance.

As the corrections resulting from the introduction of the term $\frac{\Delta h}{D}$ would only be applied to observations made with the best instruments, we need but deduce the formulæ, and tables for the corrections to meridian observations. In other words the corrections to the observed times of meridian transit, and to the reduced zenith distances. Let $\Delta\alpha$ and Δz denote these corrections, then we evidently have, since $\Psi''=0$

$$\Delta\alpha=\frac{a}{15}\,\frac{\Delta h}{D}\cos z\sin\Psi\sec\delta$$

$$\Delta z=a\frac{\Delta h}{D}\sec^2 z\cos\Psi.$$

Thus far we have assumed the temperature to be constant; as however this is not the case, the above values will be largely in error unless similar terms allowing for the change in temperature are included in the expressions for $\Delta\alpha$ and Δz.

According to Bessel the coefficient of expansion of atmospheric air is $\varepsilon=0{\cdot}002$ (nearly) for each degree Fahrenheit. Now, if at two stations, on the same level (separated by the distance D), p_1 and p_2 are the simultaneous pressures when the corresponding temperatures are τ_1 and τ_2, the refraction at the second station expressed in terms of the refraction at the first station will be given by the equation*

$$r_2=r_1\left(\frac{1}{1+\varepsilon(\tau_2-\tau_1)}\,\frac{p_2}{p_1}\right).$$

For, the values of r_1 and r_2, for temperatures and pressures different from the assumed normal values, will be in error by practically the same amount, and as we have only to deal with the differences in the refractions at the two stations, the results obtained will not, in general, be sensibly in error. The last equation, if we neglect small quantities, can be put into the following form:

$$r_2-r_1=a\left(\varepsilon(\tau_1-\tau_2)+\frac{p_2-p_1}{p_0}\right)\tan z.$$

p_0 being the assumed normal height of the barometric column, which in Bessel's refrection tables is taken at 29·6 inch, while his value of a is $57''{\cdot}75$ for $z=0$, varying (at first slowly) to $55''{\cdot}75$ for $z=80°$. By equating the barometric and thermometric terms we find $p_2-p_1=-0{\cdot}059$ inch $(\tau_2-\tau_1)$. An increase of 10° in the temperature therefore produces nearly the same change in the refraction, as does a decrease of 0·59 inch in the pressure.

* See Chauvenet's Spherical and Practical Astronomy, vol. i, p. 160.

Now the term $r_2 - r_1$ being due to the difference in the density of the atmosphere at the two stations, the layers of the same density will not be parallel to the horizon. The equivalent inclination of the layers of equal pressure, for a uniform temperature, will depend upon the term $\frac{p_2 - p_1}{p_0} = \Delta h$, while the inclination of the layers of equal density, for a uniform pressure, will depend upon the term $\varepsilon(\tau_1 - \tau_2) = \Delta h'$. These layers will not necessarily be inclined in the same direction.

The tri-daily weather maps of the U. S. Signal Service, will generally furnish all the necessary data for finding the amount and direction of inclination for points in the United States.

Let D denote the length of the shortest line that can be drawn, on the map (through the point of observation) connecting two isobars, one being on each side of the station, and let Ψ denote the angle which this line makes with the meridian, reckoned from the south point toward the west through 360°. Let the similar data for two isotherms be D′ and Ψ'; the angles being in the quadrants of greater pressure and temperature respectively. The component inclinations in the prime vertical and meridian planes will then be respectively,

$$\frac{\Delta h}{D} \sin \Psi, \quad \frac{\Delta h'}{D'} \sin \Psi', \quad \text{and} \quad \frac{\Delta h}{D} \cos \Psi, \quad \frac{\Delta h'}{D'} \cos \Psi'.$$

Hence the complete expressions for $\Delta\alpha$ and Δz will become

$$\Delta\alpha = \frac{a}{15}\left(\frac{\Delta h}{D} \sin \Psi + \frac{\Delta h'}{D'} \sin (180° + \Psi')\right) \cos z \sec \delta$$

$$\Delta z = a\left(\frac{\Delta h}{D} \cos \Psi + \frac{\Delta h'}{D'} \cos (180° + \Psi')\right) \sec^2 z.$$

If D and D′ are expressed in miles, Δh and $\Delta h'$ must also be expressed in the same unit. As the adjacent lines on the maps differ by 0·10 inch for the isobars, and by 10° F. for the isotherms, we have*

$$\Delta h = \frac{0{\cdot}10}{29{\cdot}6}\, 5{\cdot}12 \qquad \Delta h' = \frac{0{\cdot}59}{29{\cdot}6}\, 5{\cdot}12.$$

Now let b denote the inclination of the axis of rotation of a meridian instrument, then if for b we substitute

$$b + a\left(\frac{\Delta h}{D} \sin \Psi + \frac{\Delta h'}{D'} \sin (180° + \Psi')\right)$$

and use this value in the reduction of the observations, the corrections to the times of transit, for meridian refraction in right ascension, will be wholly allowed for.

* If still greater accuracy is desired, the mean of the two given pressures should be used in place of 29·6.

In order to show the facility with which these corrections are applied, as well as to give a general idea of the magnitude of the corrections, the following tables are given:

I.

D' miles.	$a\frac{\Delta h'}{D'}$.	$a\frac{\Delta h}{D}$.	D miles.
10	0″·59	0″·10	10
20	·30	0·05	20
30	·20	·03	30
40	·15	·03	40
50	·12	·02	50
60	·10	·02	60
70	·08	·01	70
80	·07	·01	80
90	·07	·01	90
100	0·06	·01	100

II.

Ψ	sin.	
0°	0·00	90
10	·17	80
20	·34	70
30	·50	60
40	·64	50
50	·77	40
60	·87	30
70	·94	20
80	·98	10
90	1·00	0
	cos	Ψ

III.—*Corrections to the reduced zenith distances.*

$\Psi = 0$ $\quad a\frac{\Delta h'}{D'}\sec^2 z.$

D'	z								
	0°	10°	20°	30°	40°	50°	60°	70°	80°
10	0″·59	0″·61	0″·67	0″·79	1″·00	1″·42	2″·35	4″·99	18″·87
20	·30	·30	·33	·39	·50	·71	1·17	2·50	9·43
30	·20	·20	·22	·26	·33	·47	·78	1·66	6·29
40	·15	·15	·17	·20	·25	·36	·59	1·25	4·72
50	·12	·12	·13	·16	·10	·28	·47	1·00	3·77
60	·10	·10	·11	·13	·17	·24	·39	·83	3·14
70	·08	·09	·10	·11	·14	·20	·34	·71	2·69
80	·07	·08	·08	·10	·13	·18	·29	·62	2·38
90	·07	·07	·07	·09	·11	·16	·26	·56	2·10
100	·06	·06	·07	·08	·10	·14	·23	·50	1·89

$\Psi = 0$ $\quad a\frac{\Delta h}{D}\sec^2 z.$

D	z								
	0°	10°	20°	30°	40°	50°	60°	70°	80°
10	0″·10	0″·10	0″·11	0″·13	0″·17	0″·24	0″·40	0″·85	3·20
20	·05	·05	·06	·07	·08	·12	·20	·42	1·60
30	·03	·03	·04	·04	·06	.08	·13	·28	1·07
40	·02	·02	·03	·03	·04	·06	·10	·21	·80
50	·02	·02	·02	·03	·03	·05	·08	·17	·64
60	·02	·02	·02	·02	·03	·04	·07	·14	·53
70	·01	·01	·02	·02	·02	·03	·06	·12	·46
80	·01	·01	·01	·02	·02	·03	·05	·11	·40
90	·01	·01	·01	·01	·02	·03	·04	·09	·37
100	·01	·01	·01	·01	·02	·02	·04	·08	·32

To obtain the correction to be applied to the level constant h, of the instrument, we have but to multiply the values $a\frac{\Delta h'}{D'}$ and $a\frac{\Delta h}{D}$ taken from table I, with the arguments D′ and D, by the *sines* of the angles $180°+\Psi'$ and Ψ respectively, and take the algebraic sum of the products. Similarly the quantities in table III are to be multiplied by the *cosines* of the angles $180°+\Psi'$ and Ψ respectively. For stars north of the zenith Δz must have the opposite sign from that given by the equation.

An inspection of the weather maps of the Signal Service, as published by the War Department, will show that the distance between two adjacent isobars or isotherms is frequently less than thirty miles, and at times not more than one-half of this distance. As the times of observations will not in general correspond with the times for which the maps are constructed, the values of D, Ψ and D′, Ψ', can when necessary, be interpolated for the middle time of the observations and assumed to remain constant for the series. A glance at the map will at once indicate whether the corrections will be sensible or not. At an isolated station, if the hourly thermometric and barometric changes are noted, the observer can still deduce the corrections, provided he has any means for finding the velocity and direction of motion of the thermometric and barometric waves.

The most reliable data would of course be obtained from simultaneous observations made (while the astronomical work is going on), at three or more nearly equidistant stations on the same level and lying within a radius of fifty miles. One of these stations would be at the observatory itself.

Where the aim of an observatory is to determine *absolute* positions, an arrangement of this kind, if not indispensable, is at least most desirable.

Ann Arbor, Mich., March 18, 1884.

Postscript.—The formulæ for finding the magnitude and direction of inclination of the strata from observations made at three stations, can be reduced to very simple forms. Let h_0 denote the height of a layer of given density at the point of observation, and let h_1 and h_2 be the heights of the layer at the stations whose azimuths are A_1 and A_2, the distances being D_1 and D_2. Let

$$\frac{h_1-h_0}{D_1}=i_1 \quad \text{and} \quad \frac{h_2-h_0}{D_2}=i_2,$$

($h_1-h_0=\Delta h$, etc. being found according to the method already given). If $\frac{\Delta h}{D}=i$ denotes the inclination of the strata to the horizon, we have, with all desirable accuracy, the equations

$$i\cos(A_1-\Psi)=i_1 \qquad i\cos(A_2-\Psi)=i_2.$$

As A_1 and A_2 are constants, let us put $\frac{A_2+A_1}{2}=A_0$ and $\frac{A_2-A_1}{2}=A'_0$; the above equations then become

$$i\cos(A_0-\Psi)=\frac{i_2+i_1}{2\cos A'_0}$$

$$i\sin(A_0-\Psi)=\frac{i_2-i_1}{2\sin A'_0}$$

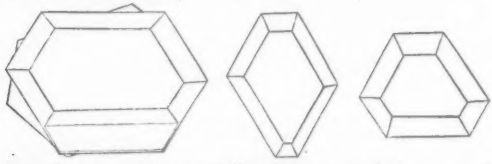
from which i and Ψ are easily found. The most favorable values of A_1 and A_2, give $A_2-A_1=\pm 90°$. The angle Ψ' should (in order to use the formulæ already given for $\Delta\alpha$ and Δz) be taken in the quadrant of greatest temperature; then in order that i may always be considered positive we substitute, as before, the value $180°+\Psi'$ in the equations for $\Delta\alpha$ and Δz. The argument D can be found by means of table I from the expression $ai=a\frac{\Delta h}{D}$.

Ann Arbor, April 12, 1884.

ART. LVII.—*Kaolinite, from Red Mountain, Colorado;* by RICHARD C. HILLS.

AT a recent meeting of the Colorado Scientific Society, Mr. Whitman Cross called attention to an interesting variety of kaolinite found by the writer in the National Belle mine at Red Mountain, Ouray County, Colorado.

The appearance of the mineral in question is that of a mass of small glistening white scales visible to the naked eye. Under the microscope these scales are resolved into remarkably perfect transparent crystals, all of which differ from those hitherto described under the head of kaolinite in the development of well-defined pyramidal planes, to the exclusion, in most instances, of those in the prismatic zone. The general form is shown in the annexed diagram, which is a camera lucida drawing of three of the observed crystals.



The mineral occurs in considerable quantities, associated with galena and its oxidation products, in the huge vuggs, or chambers lined with ore, found irregularly distributed through an immense mass of quartz, the latter being enclosed in a highly kaolinized rock of eruptive origin.

ART. LVIII.—*The influence of Convection on Glaciation;* by GEO. F. BECKER.

THE suggestion made by Captain Dutton,* that the increase of precipitation due to a higher sea-level temperature might conceivably be confined to regions below the isotherm of 0° C., is one of such extreme simplicity that I can scarcely believe it to have escaped the physicists and geologists who have written on glaciation. Some months since I ventured to contribute a few pages† to the discussion, which were not written, however, until I had carefully considered the possibility which my colleague has since brought forward. I arrived at the conclusion that though conceivable, it was inapplicable to terrestrial conditions; but before giving the reasons for this conclusion I beg leave to restate the problem as I understand it.

This can be done in two ways, of which the first and most usual is: Given a definite locality, the mean temperature of which is now compatible with the existence of glaciers, will an increase of temperature at sea-level tend within certain limits to increase the accumulation of ice upon it? In this form the question is one of great complexity, for it involves a knowledge of all the climatic changes which would accompany a change of sea-level temperature. A portion only of these are known with any sort of approximation, and the gaps must be filled with assumptions which every opponent is at liberty to deny.

The second method of stating the problem is as follows: If two periods of different sea-level temperature and correspondingly different permanent snow-lines are compared, which will show the greater accumulation of ice above its own snow-line under similar topographical conditions? This question, which is that to which I attempted to give an answer in my former paper, appears comparatively simple, for it does not compel any definite assumption as to the relation between elevation and temperature.

As I understand Captain Dutton, he would reply to this latter question that the accumulation in each period would be the same, the whole excess of moisture of the warmer period falling as rain below the snow-line. His statement might have been made somewhat more broadly, for the same argument shows that upon his suppositions the precipitation above any isotherm is independent of the temperature at sea-level. If, for example, the characteristic temperature at sea-level in the cooler period were 10° and in the warmer period 20°, then the entire excess of moisture evaporated during the warmer period would

* This Journal, vol. xxvii, p. 1. † This Journal, vol. xxvii, p. 167.

be precipitated below the isothermal line or surface characterized during the same period by a temperature of 10°. His suppositions are two: that the atmosphere is saturated (unless special exception is made, which is not the case in his concluding remarks), and, as the results of a calculation that the difference in the velocity of the wind in the two periods is insignificant. Granting for the sake of argument the insignificance of the difference in the velocity of the wind,* it is certain that, if the supposed complete saturation of the atmosphere would produce no essential alteration in the problem, Captain Dutton's result is immediate and inevitable; but as complete saturation represents an extreme case, it seems desirable to examine its bearing on the results.

No one of course would think of denying that the mean saturation of the whole atmosphere is never complete nor even the mean saturation of the portion of it which is in immediate contact with the sea. All know, on the contrary, that descending currents of relatively dry air constantly mingle with the moist air at the sea-level, more or less reducing its vapor contents. A similar process goes on at every level, and all must, I think, admit not only that complete saturation of any entire stratum of the atmosphere has never been observed, but that such a phenomenon cannot have taken place at least during later geological epochs. At every level above the surface of the earth the rise of air bodies, and sometimes other causes, tend to chill the air below its dew-point, while at the same time the continual admixture of drier air from higher regions tends to dilute the vapor and to keep it in the gaseous form. Precipitation therefore must be, as it certainly is, a local phenomenon induced by circumstances which favor the chilling of the air while (absolutely or relatively) retarding the intermixture of dry air with the moist. Were it not for the constant return to the surface of desiccated currents, evaporation must evidently altogether cease. On the other hand so long as precipitation takes place, air must be more or less completely desiccated and the process of distillation must continue.

More or less completely saturated air from the surface mingled with dry air from above forms a mixture, the dew point of which is considerably below the temperature of sea-level, and such a mixture may of course rise to the isothermal surface corresponding to its own dew point without precipitation. The process of admixture however is in general continuous, taking place at all levels, and it cannot be asserted of any particular molecule of vapor that it may not reach the confines of the atmosphere unprecipitated.

*It appears to me improbable that the additional energy which a warmer climate would impart to the air currents would be distributed simply among existing currents.

If a comparison is made between a warmer and cooler period, the conditions otherwise being equal, it will not be denied by any one that the lower strata of the warmer atmosphere contain a greater absolute amount of moisture than the lower strata of the cooler atmosphere, but on Captain Dutton's suppositions this excess is confined entirely to the lower strata. Suppose this condition of things to exist at a given instant. Then if the descending dry currents come into play and the tendency of the warm, moist surface air to rise is taken into consideration, it appears that a portion of this excess will be carried upward by convection and be added to the moisture of higher strata as explained in the preceding paragraphs. And though a part of this additional moisture might and probably would be precipitated at various levels, I cannot avoid the conclusion that, by the continuous admixture of dry air, a part of the excess would be carried on indefinitely, or, in other words, that the absolute humidity at every isothermal surface, or the relative humidity of the whole atmosphere, would be greater during the warmer period than during the colder one. There would indeed be a very slight, as it seems to me insignificant, counteracting tendency. The humidity of the lower strata of the air could not be increased by descending currents, because a rise of temperature and an increased capacity for moisture would attend their compression in sinking,* but rain drops from upper levels fall through warmer air than that in which they form, and there must be a minute evaporation during their passage. It seems, however, hardly possible to maintain that this addition to the moisture of the atmosphere near the surface is comparable with the contrary tendency which has been enlarged upon.

It appears quite certain therefore, that the absolute humidity at what I have called the glacial isotherm (where the tendency to the accumulation of névé is a maximum, not far from 0° C.) or, what is exactly the same thing, the mean relative humidity of the air over the glacial zone, during a warmer period, will be greater than over the corresponding but not identical glacial zone during a cooler one. Precipitation at the glacial isotherm may most naturally be supposed to be simply proportional to the mean relative humidity. It is indeed conceivable that though the mean saturation during the warmer period at this isotherm would be greater, complete saturation might be more seldom attained; but I know of nothing tending to prove such a relation. On the other hand, as I showed in my former paper, the empirical inference from observations on the diminution of temperature with altitude along mountain slopes is, that the higher the sea-level temperature the more rapid would be the decrease of temperature at the glacial isotherm, a relation

* It is of course supposed here that the sea-level temperature remains constant.

which would tend to increase precipitation at this line independently of the relative humidity; so that if the relation between relative humidity and precipitation is not simple and direct, it is probable that precipitation at the glacial isotherm increases more rapidly rather than less rapidly than the relative humidity.

I must conclude therefore, as I did before, that "the rate of decrease of temperature and the mean saturation will probably be greater in the warmer period . . . near the glacial isotherm," and indeed on the same grounds, for I prepared a passage for my former paper presenting in a more condensed form precisely the arguments here offered, but omitted it as being manifest without special mention.

The argument here presented does not include all the important factors involved in the relations of temperature to glaciation, some of the others being sketched in my previous paper. That here offered, however, may serve to show the essential part which convection plays in the distribution of precipitation.

San Francisco, Office U. S. Geological Survey, Feb., 1884.

ART. LIX.—*A New Dinicthys from the Portage Group of Western New York;* by EUGENE N. S. RINGUEBERG.

TAKING advantage of one of the pleasant days of January to make a short trip, down among the black carbonaceous shales of the Portage Group, to a fine exposure extending along the lake shore at Sturgeon Point, a projection of land about twenty miles below Buffalo, principally for the purpose of obtaining some of the Calamites found there, I was so fortunate as to obtain, besides a quantity of undetermined fish scales, the fossil here described.

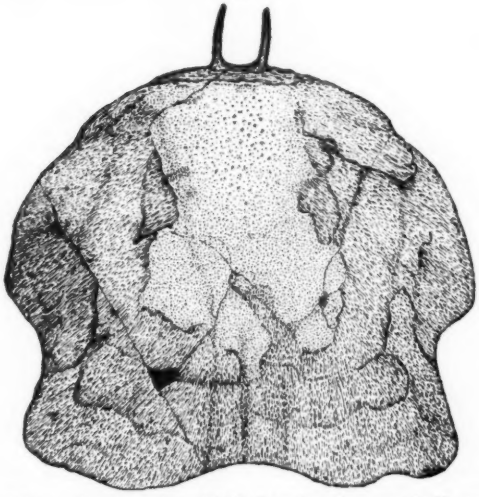
Immense placoderms of the genus *Dinicthys* have been known for quite a number of years past from the Huron shales of Ohio; but none till now have been recognized from its equivalent in this State.

The specimen found consists of a dorsal shield belonging to a *Dinicthys* which exhibits such distinctive specific variations from the two Ohio species, *D. Hertzeri* and *D. Terrelli* Newb., both in size (which is only one-fifth of that of the largest of this species), and in form, as to require a specific description.

Dinicthys minor (n. sp.)

Dorso-median shield. Surface having a fine grained rugose appearance. Plate gently arched anteriorly and gradually sloped toward the flattened posterior margin which is but slightly arched.

1.



Dinicthys minor. Dorso-median shield, dorsal surface, one-half natural size.

2.

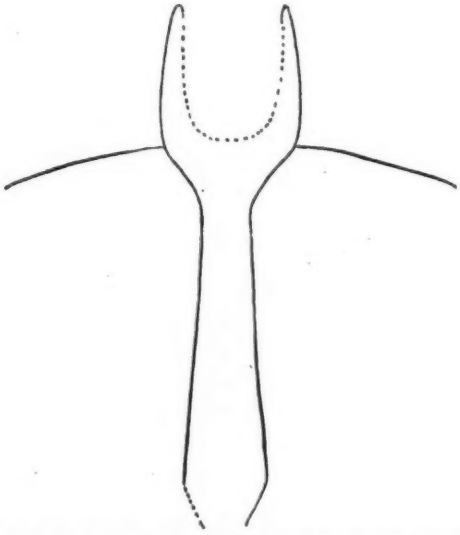


Diagram of anterior inferior surface, natural size, showing all that is exposed to view of the inferior median crest or spine, the specimen being embedded in a slab of shale.

Anterior margin describing an almost perfect semicircle of five and one-half inches in diameter, which comprises the anterior five ninths of the plate, and represents its widest extension; a slight sinus half way from the crest on either side. The highest point of the shield is on a ridge situated a little back from the anterior median margin and extends at right angles across the upper part, from which elevation the surface is beveled off toward the outer margin.

Posterior portion rather squarish, strongly sinuate; the two lateral sinuses sharply cut out nearest the forward part, where they end with a well defined angle at their junction with the anterior semicircular portion; posteriorly, curving around the sub-obtuse latero-anterior angles into the lateral posterior sinuses. Posterior margin with a wide shallow median sinus, and two smaller lateral ones.

The latero-posterior angles are placed on a line with the central portion of the median sinus, and the shield is one-half inch narrower here than at the median transverse diameter. A slight median longitudinal depression along the central portion of the lateral third.

Under side concave; divided into two lateral fossæ by a strong longitudinal spine or crest projecting anteriorly beyond the margin of the shield, where it bifurcates. It projects one-half inch downward from the plate near the anterior border where it is about one-fourth of an inch thick and from which it gradually enlarges to three-eighths of an inch at a point about one-third of the length of the plate from the border, when it rapidly tapers off.

The projecting portion of the spine widens out and bifurcates into two thin perpendicular plates; which, after passing somewhat beyond the margin rapidly slope downward and forward, terminating in two sharp points on a plane with the lower border of the inferior crest, one-half inch apart, with a projection of five-eighths of an inch beyond the plate.

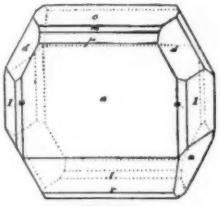
Length of plate, exclusive of spine, four and one-half inches. Median portion one-eighth of an inch in thickness. The right lateral sinus in the specimen figured is slightly deeper than the left. It must have been of large size, though but a pigmy compared with its congeners of the adjacent seas, some of which were from two to three feet across their armor-clad backs.

ART. LX.—*Mineralogical Notes;* by EDWARD S. DANA.

1. ALLANITE.

SOMEWHAT more than a year since, Professor James Hall placed in the hands of the writer a crystal of allanite for crystallographic description. This crystal was obtained from the magnetite ore bed at Moriah, Essex County, New York. This locality has in time past afforded specimens of the same mineral and sometimes of very considerable size, but the crystal in question is remarkable for this locality and the species, both in respect to size and perfection of form. The crystal is tabular in form, through the predomination of the orthopinacoid, and is in general rectangular in outline. It measures about $3\frac{3}{4}$ by $4\frac{1}{2}$ inches; the planes are smooth, their intersection lines mostly sharply defined and the entire crystal is nearly perfect and symmetrical except where the surface is penetrated by magnetite. The habit of the crystal is shown in the adjoining figure,* which is one-fourth of the natural size. The occurring planes are as follows:

i-i	(100, a)	-1-i	(101, μ)
O	(001, c)	$+1$-i	($\bar{1}$01, r)
I	(110, I)	$+2$-i	($\bar{2}$01, l)
i-2	(210, u)	1-i	(011, o)
$-\frac{1}{2}$-i	(102, m)	-1	(111, d)
		$+1$	($\bar{1}$11, n)



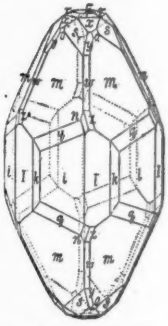
Allanite.

The position here adopted is that of Kokscharof (Min. Russl., iii, 344), and the letters are the same as his except those of the pinacoids and the unit prism: $a=T$, $c=M$ and $I=z$. For comparison it should be stated that in the figures on p. 286, Dana's System, 5th edition, 1-i is the orthopinacoid, and i-i the basal pinacoid of Kokscharof (a and c respectively of the above figure); the position taken in Dana's System is that of Mohs. The angles on this crystal could be measured only with the contact goniometer, and hence they are not sufficiently accurate to give a basis of comparison with those obtained in more favorable circumstances; they are consequently not quoted here; in general it may be said that they agreed satisfactorily with those generally accepted for the species.

* This figure was inserted by mistake of the printer, in a paper by the present writer on Stibnite in the number of the Journal for September, 1883 (III, xxvi, p. 217).

2. Apatite.

Several years ago the writer, through the kindness of Mr. Samuel R. Carter of Paris, Me., was able to examine a crystal of apatite of so unusual form as to deserve a special notice. The examination was completed at that time but the results are now for the first time published. The crystal was from the tourmaline locality at Paris, Me., and when received was partly coated by a film of cookeite which, however, readily scaled off, leaving the planes beneath uninjured. The crystal was small, about one-fourth of an inch in length, and had a deep blue color. The form of the crystal is given in the adjacent figure; it is remarkable both for its complexity and also because the pyramidal termination is essentially formed by a pyramid of the third order. The occurrence of these hemihedral forms on apatite is common, but they are usually subordinate, being only modifications of the predominating simple form. The pyramidal angle in this case ($21\bar{3}1 \wedge 3\bar{2}\bar{1}1$) is 51° 37′. The planes here present are:



O	(0001, c)	$\frac{7}{3}$	($70\bar{7}3$, w)*
I	($10\bar{1}0$, I)	3	($30\bar{3}1$, z)
i-2	($11\bar{2}0$, i)	2-2	($11\bar{2}1$, s)
$+\frac{1}{2}(i\text{-}\frac{5}{4})$	($\pi 41\bar{5}0$, k)	$+(2\text{-}\frac{4}{3})$	($\pi 31\bar{4}2$, o)
$\frac{1}{2}$	($10\bar{1}2$, r)	$+(3\text{-}\frac{3}{2})$	($\pi 21\bar{3}1$, m)
1	($10\bar{1}1$, x)	$+(7\text{-}\frac{7}{4})$	($\pi 43\bar{7}1$, q)*
2	($20\bar{2}1$, y)	$-(4\text{-}\frac{4}{3})$	($\pi 13\bar{4}1$, n)

Of these planes, the two marked by an asterisk are new to the species, namely $\frac{7}{3}$ (w), which was determined by the fact of its being in the zone I to O, and also in the zone between m and m ($21\bar{3}1$ and $3\bar{2}\bar{1}1$). The form $7\text{-}\frac{7}{4}$ (q) was determined in part by the zone i-2, $3\text{-}\frac{3}{2}$, etc. ($11\bar{2}0$, $21\bar{3}1$), and also by the measured angle on i-2=11° to 12°. The planes q were uniformly rough and allowed of only approximate measurements. The calculated angles for both these forms (taking $c=0{\cdot}734603$ as given by Kokscharof) are:

$O \wedge \frac{7}{3}$,	$0001 \wedge 70\bar{7}3$	=	63° 12′
$I \wedge \frac{7}{3}$,	$10\bar{1}0 \wedge 70\bar{7}3$	=	26 48
$O \wedge 7\text{-}\frac{7}{4}$,	$0001 \wedge 43\bar{7}1$	=	79 2
$I \wedge 7\text{-}\frac{7}{4}$,	$10\bar{1}0 \wedge 43\bar{7}1$	=	27 25
$i\text{-}2 \wedge 7\text{-}\frac{7}{4}$,	$11\bar{2}0 \wedge 43\bar{7}1$	=	11 56

3. Tysonite.

Mr. S. T. Tyson recently showed to the writer a large specimen of the rare species tysonite from Colorado, described by Allen and Comstock and proved by them to be a fluoride of the cerium metals (this Journal, III, xix, 390, 1880). This specimen is much the largest which has yet been found, having a weight of no less than two and a half pounds. It was very homogeneous and only on one side showed a partial alteration to bastnäsite; it exhibited very distinctly the characteristic basal cleavage of the species. At one point the summits of a few crystals were observed, and through the kindness of Mr. Tyson the writer has been able to obtain some data to complete the description of the species. The original crystals showed only the basal plane and the prisms of the first and second order (*I*, and *i*-2). The crystals now in hand, or rather crystalline fragments, showed in addition the planes **1**, **2**, and **2-2**. It was furthermore observed on them that the mineral has a distinct cleavage parallel to the unit prism *I*. The observed planes for the species are then:

O	(0001, *c*)	1	$(10\bar{1}1, p)$
I	$(10\bar{1}0)$	2	$(20\bar{2}1, q)$
i-2	$(11\bar{2}0, i)$	2-2	$(11\bar{2}1, s)$

On two crystals the angle between *O* and **1** admitted of accurate measurement; the result was

$$O \wedge 1, \quad 0001 \wedge 1011 = 38^\circ 25' \text{ and } 38^\circ 24\tfrac{1}{2}'$$

Of these the former is accepted as the fundamental angle, as the planes affording it were best suited to give accurate results. The length of the vertical axis is then

$$c = 0{\cdot}68681;$$

and the more important angles calculated from it are:

			Calculated.	Measured.
O ∧ 1,	$0001 \wedge 10\bar{1}1$	=	38° 25′*	38° 25′ and 38° 24½′
∧ 2,	$\wedge 20\bar{2}1$	=	57 46	57 42
∧ 2-2,	$\wedge 11\bar{2}1$	=	53 57	53 42 approx.
I ∧ 1,	$10\bar{1}0 \wedge 10\bar{1}1$	=	51 35	
∧ 1 (ov. 2-2),	$10\bar{1}0 \wedge 01\bar{1}1$	=	71 54	
∧ 2,	$\wedge 20\bar{2}1$	=	32 14	
∧ 2-2,	$\wedge 11\bar{2}1$	=	45 34	
i-2 ∧ 2-2,	$11\bar{2}0 \wedge 11\bar{2}1$	=	36 3	
1 ∧ 2-2,	$10\bar{1}1 \wedge 11\bar{2}1$	=	26 20	26 50 approx.
1 ∧ 1 (pyr.),	$10\bar{1}1 \wedge 01\bar{1}1$	=	36 12	
1 ∧ 1 (basal),	$10\bar{1}1 \wedge 10\bar{1}\bar{1}$	=	103 10	

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *New Determinations of Atomic Weights.*—The results which have recently been reached with the rarer earths by successive fractional precipitations or decompositions, showing that elements whose oxides are closely allied in properties may yet have widely different atomic weights, have led Marignac to submit some of the more common oxides to a similar course of fractional precipitations in order to detect any progressive variation in the atomic weight. In the case of bismuth, a solution of the nitrate was fractionally precipitated by water, the basic nitrate converted into the oxide by ignition and this reduced by hydrogen to the metal. Six experiments gave 208·62, 208·92, 208·58, 208·82, 208·08, 208·56; the mean being 208·60. A second set of experiments was made by converting a known weight of the oxides obtained by fractioning into sulphates and weighing. Six determinations gave 208·06, 207·94, 208·13, 208·33, 208·11 and 208·36; or 208·16 as the mean. To prepare the manganese oxide the nitrate was partially precipitated by oxalic acid, the filtrate evaporated to expel excess of nitric acid, diluted and again precipitated with oxalic acid as before. Seven separate fractions as oxalates were thus obtained, of which 1, 3, 5 and 7 were converted into oxide by roasting, and this reduced to manganous oxide by hydrogen at a high temperature. By converting a known weight of this oxide into sulphate, the atomic weight of manganese was found to be 55·12, 55·03, 55·07, 55·06; or 55·07 as a mean. For the determination of the atomic weight of zinc, five successive products were obtained by partial decompositions of the nitrate by heat. The oxide was at first converted into sulphate, in order to determine by the increase of its mass, the atomic weight. But the results were not satisfactory. It was then converted into the double chloride of potassium and zinc, and the chlorine determined in a weighed portion by titrition. The values found were 65·26, 65·22, 65·37, 65·31 and 65·28; or 65·29 as a mean. Three subsequent determinations made upon specially purified crystals gave 65·28, 65·39 and 65·32; or 65·33 as a mean. For the determination of the atomic weight of magnesium two sets of experiments were made. In the first, magnesium nitrate was fractionally calcined, giving five successive products of oxide; the sulphate was thus calcined giving three specimens of oxide; and the carbonate thus treated gave two specimens. These samples of oxides were all converted into sulphates and weighed, giving 24·40, 24·37, 24·37, 24·39, 24·40, 24·37, 24·36, 24·37, 24·38, 24·38; or 24·38 as a mean. In the second set, fractionally crystallized specimens of sulphate were calcined, giving six specimens of oxide; the sulphate fractionally precipitated by alcohol was calcined, also giving six specimens;

and a last fraction of the sulphate was calcined, which had crystallized from an acid solution. The values obtained were 24·38, 24·35, 24·39, 24·37, 24·35, 24·37, 24·41, 24·37, 24·37, 24·37, 24·36, 24·38, and 24·37; excluding the seventh as erroneous from the presence of a trace of calcium, the mean of the above values is 24·37 for magnesium.—*Ann. Chem. Phys.*, VI, i, 289, March, 1884.

G. F. B.

2. *On a new reaction of Ethyl Carbamate.* — The substance $C_{11}H_{19}NO_2$, obtained by Haller by the action of cyanogen on sodium-borneol, was observed to split up under the action of alcoholic potash into potassium cyanate, water and borneol. The body $C_{11}H_{21}NO_2$, obtained by Arth by acting similarly on menthol splits in the same way. As these bodies have the composition and properties of carbamic ethers, the latter chemist undertook an examination to ascertain whether this behavior was characteristic of the class of urethanes. On submitting ethyl carbamate to the action of boiling alcoholic potash in a flask with an upward condenser for half an hour, the liquid contained abundant hard brilliant crystals of potassium cyanate. The mother liquor evaporated with ammonium sulphate readily gave urea. Hence the above reaction is general.—*Bull. Soc. Chim.*, II, xli, 334, April, 1884. G. F. B.

3. *On the synthesis of a Glucoside of Tartaric acid.* — Guyard has succeeded in effecting the synthesis of a glucoside of tartaric acid, by projecting the anhydrous tartaric acid of Fremy into melted glucose until the mixture becomes pasty and less fusible. An abundant evolution of aqueous vapor is observed and the resulting product is white, soluble readily in water, and unaltered by prolonged ebullition. The presence in it of neither glucose nor tartaric acid can be detected. If boiled for a few minutes with a dilute acid, glucose and tartaric acid result.—*Bull. Soc. Chim.*, II, xli, 291, March, 1884. G. F. B.

4. *On the Physical Isomerism of Camphol-urethanes.* — The substance obtained by Haller by the action of cyanogen on right-sodium-camphol, and which has been shown by Arth above to be a camphol-urethane, rotates the polarized beam to the right and crystallizes in hemihedral crystals. Haller has now prepared this urethane from left-camphol obtained from the borneol of Ngaï. Its aqueous solution on cooling deposited crystals of left-camphol-urethane in fine needles melting at 126°–127°. The solution rotates the polarized beam to the left $\alpha D = -29{\cdot}90°$. The crystals while hemihedral like those of right-camphol-urethane, are so in an inverse sense. In the right-handed variety certain planes exist only on one side of the crystal while they are absent on the other. In the left-handed variety these planes are present but in an opposite sense, being on the left side instead of the right. These two camphol-urethanes present in their crystals the same kind of physical isomerism relatively to each other that Pasteur observed in the right and left ammonium-sodium tartrates. The borneol carbonate formed simultaneously with the urethane is

the same whether the camphol be right or left, having the constant fusing point of 226°–227°. By the action of alcoholic potash it splits into camphol and potassium carbonate.—*Bull. Soc. Chim.*, II, xli, 327, April, 1884. G. F. B.

5. *On a relation between the Capillary constant of a Liquid at the boiling-point, and its Chemical composition.*—SCHIFF has succeeded in obtaining a relation between the capillary constant of certain liquids and their chemical composition, by determining this constant at the boiling point. For this purpose a U-tube was employed, the two sides of different diameters, hung in the vapor of the liquid with which it was filled. From the difference of level in the two legs, the capillary constant was readily calculated. Beside this value, which the author represents by a^2, he uses $\frac{1}{2}a^2s$ to represent the weight of the raised liquid for unit length of the contact line, where s is the specific gravity of the liquid. If m = the molecular weight, $\frac{m}{s} = v$, the molecular volume, and $\frac{\frac{1}{2}a^2s}{m} = \frac{\frac{1}{2}a^2}{\frac{m}{s}} = \frac{a^2}{2v} = N$, the relative number of molecules raised per unit length of the contact line between the liquid and the wall of the solid. Since the value of N is small, the author multiplies it by 1000. The results of the measurements are given for 60 organic liquids, water being first measured. For this liquid, a^2 was found to be 15·090 at 8·9°. Hexane gives a^2=4·514, $\frac{1}{2}a^2s$=1·386, and N = 16·1 at the boiling point, 68·1°. For ethylbenzene the values are, a^2=4·495, $\frac{1}{2}a^2s$=1·710, and N=16·2 at 135·9°. Ethyl alcohol, a^2=4·782, $\frac{1}{2}a^2s$=1·765 and N=38·4 at 78°, etc. Comparing now together chemically analogous bodies, the values of a^2 and of N are closely similar. Thus isobutyl-alcohol, ethyl formate and ether, bodies which have different boiling points though the same molecular weights, 73·84, have the following values of a^2: 4·416, 4·528, 4·521. And the isomers methyl butyrate, propyl acetate and ethyl propionate give for N the values 15·9, 15·6 and 15·6. Moreover, it appears that among the isomers of the fatty series those with the highest boiling points show the greatest capillary elevation, the greater number of raised molecules, while the converse holds with the aromatic series. If, now, those substances be compared which give practically the same value for N, as for example 16, we have hexane C_6H_{14} giving for N 16·1, the xylenes and ethylbenzene C_8H_{10}, giving 16·0, 15·9, 15·8 and 16·2, and compound ethers of the formula $C_5H_{10}O_2$, giving 15·8, 15·6, 15·6, 15·9 and 15·7. Now C_6H_{14} has C_2 less and H_4 more than C_8H_{10}. Hence, relatively to the constant N, C_2=H_4. So C_8H_{10} has C_3 more and O_2 less than $C_5H_{10}O_2$; and therefore C_3=O_2. Other groups give the same results. From the above it follows that C=H_2 and O=H_2. From dimethyl-acetal and chloroform it appears that Cl=H_3. These values enable us to substitute a certain number of hydrogen atoms for

the chlorine, carbon and oxygen atoms in any molecule and thus to formulate a substance which, if it could exist in the free state would have the same capillary constant as the original body. Hence, two substances having the same value for N, may by means of these equivalents be represented by the same number of hydrogen atoms. Thus $CH_4O=H_9$, the value of N being 59·8; $C_4H_8O_2=H_{22}$, N being 20·4; $C_8H_{16}O_2=H_{38}$, N being 8·7; and so on. If a curve be drawn with these hydrogen values as ordinates and the corresponding values of N as abscissas, then obviously, having given any substance containing C, O, H or Cl, its formula may, by using the above equivalences, be translated into its hydrogen equivalent and then from the curve, its capillary constant be obtained. In other words, from the molecular formula of a substance, its capillary constant at the boiling point may be calculated. Since $N=\frac{1}{2}a^2 \div v$, the value of either a or v (the molecular volume) may be calculated if the other is known. The calculated and observed values of N as given in the paper are very close. With regard to the equation of the curve, which is concave toward the axis of abscissas, the author finds it to be $y=\frac{1}{x} \cdot e^{6\cdot48292s-0\cdot0167628x}$, the equation of a logarithmic curve. A complete table of the liquids tested, their formulas and values of a^2, $\frac{1}{2}a^2s$, and N, concludes the paper. — *Liebig's Annalen*, ccxxiii, 47, March, 1884. G. F. B.

6. *On the Discovery of the Periodic Law and on Relations among the Atomic weights;* by JOHN A. R. NEWLANDS, F.I.C., etc. 34 pp. 12mo. London, 1884 (E. & F. N. Spon).—This little volume contains a reprint of several articles by the author, in which he developed the idea of the Periodic Law in the arrangement of the chemical elements. He thus shows the extent to which he anticipated Mendelejeff in the latter's subsequent development of the same subject. The book is valuable chiefly as a contribution to the history of this important subject.

7. *Absorption Spectra of Water.*—The Society of Physics and Natural History of Geneva has appointed a committee to study the color and the transparency of the water of Lake Geneva. This committee is composed of Plantamour, Soret, Luc, de la Rive, C. de Candolle, Ed. Sarasin, Herm. Lal, L. Pictet, A. Killiet and C. Soret. Two of the committee, MM. Soret and Sarasin, have studied the absorption spectra of the water taken from different localities. The water was contained in four tubes of glass 1·10 meters in length, and 0·05 meters in diameter. One of these tubes did not produce a sensible absorption in the solar spectrum. But with two tubes, that is with a length of a little over two meters, an obscure band appeared in the orange. This band was very feeble and narrow. It was a little less refrangible than the D line and corresponded very nearly with the wave length 600. With three tubes the band is more marked and the absorption increases to the red extremity of the spectrum. With four tubes or a total thickness of nearly 4·50 meters, the band

grows darker, but still remains of a not pronounced gray tint. The water was taken from various localities—from the conduits near the city of Geneva—from the Arve. Distilled water was also used, and water freed from gases in solution and from silica. It seems difficult therefore to attribute the absorption band to impurities in the liquid and it is probably due to a selective absorption of water. Various experiments showed that it was not due to the apparatus employed. That this band has not been perceived by M. Secchi, M. Vogel and other physicists who have studied the absorptive effects of water, is probably due to the conditions under which their observations were made. The red and orange were perhaps too much enfeebled, either by the great length of water traversed by the light or by the employment of a too feeble source of light. Through four meters and even eight meters of water the author could not detect the band between E and *b* which Vogel found in the light in the grotto of Capri. This appears to indicate that this band is due to substances in solution in the water.—*Comptes Rendus*, March 10, 1884, pp. 624–626. J. T.

8. *Magnetic effect of Electrical Convection.*—Rowland's experiment upon the magnetic effect of electrical convection has been called in question by Dr. Lecher of Vienna. Dr. Lecher modified Rowland's experiment by placing the rotating disc in a vertical plane, its axis being horizontal. The magnet needle was placed parallel to the plane of the disc and in the axis of its rotation, relatively as the coil and needle of a Gaugain galvanometer. Discs of brass and *papier maché* covered with graphite were employed and were charged to potentials of about 5000 volts. No deflection was observed with a rotation of 200 revolutions per second.—*Nature*, April 10, 1884. J. T.

9. *Hall's phenomenon.*—M. Leduc has investigated, by means of a capillary electrometer, the phenomenon discovered by Mr. Hall and finds that if the strength of the magnetic field does not exceed a certain value that the deviation of the equipotential line and the line of force at the points where they meet can be represented by the formula $D=kM(1-at)$, k being the deviation produced at the temperature 0 at a point where the magnetic intensity is 1 and a is a constant. For bismuth a is very small; for silver it varies from 0·008 to 0·009. This deviation can be considered as due to a heterotrophy which the metal assumes in the magnetic field and is analogous to that which light undergoes in falling normally upon a doubly refracting substance. The phenomenon is very feeble in an alloy of bismuth and lead of equal weight which is very malleable. It is zero in lead according to Dr. Hall. The crystalline state of bismuth appears therefore to play a greater part in the production of the phenomenon than the nature of the metal itself, as also happens in the case of diamagnetism.—*Comptes Rendus*, March 17, 1884, pp. 673–675.

Mr. Shelford Bidwell, Philosophical Magazine, April, 1884, has tatempted to show that Hall's phenomenon is due to a strain, and

Peltier effect in the thin strip of metal interposed between the poles of an electro magnet, and publishes a table in which he finds great agreement between the direction of the Hall effect and the thermo-electric effect of strain in different metals. Mr. Hall has replied in Science, March 28, 1884, and shows that if the strain is proportional to the magnetic force, as Mr. Bidwell supposes, the Hall effect should be proportional not to the current, as actually is the case, but to the cube of the current.

Professor S. P. Thompson and Mr. C. C. Starling have also varied Dr. Hall's experiment by using a very large sheet of tin foil, so that the wires and connections should be entirely outside the magnetic field, and have also employed pointed electro-magnets. In this case the Hall phenomenon is not produced. An alteration in the equipotential lines due to change of resistance is noticed. Strips of gold and tin show a decrease. Strips of iron show a slight increase of resistance when subjected to a strong magnetic field.—*Physical Society, London. Nature,* April 10, 1884, p. 558. J. T.

10. *A Text Book of the Principles of Physics;* by ALFRED DANIELL, M.A., Lecturer on Physics in the School of Medicine, Edinburgh. 653 pp. 8vo. London, 1884 (Macmillan & Co.).—Teachers of Physical Science will welcome a text-book, which unlike most of the works on general Physics now in use, aims to develop the principles of the Science rather than to give a mere summary of physical phenomena. According to the modern methods of instruction a student is expected to have as wide an opportunity as possible to do practical work in the laboratory, and thus there is much less necessity, than was formerly the case, for the long descriptions of instruments and methods of experiment with which the older books are loaded down. The author treats the introductory parts of the subject with almost too great fullness, that is, the subjects of kinematics and kinetics, the different forms of matter, and so on, leaving only half the space for the development of heat, sound, radiant energy, electricity and magnetism. These latter subjects, consequently, are treated in many points too meagerly to be symmetrical with the earlier part of the work. The author uses throughout the absolute units on the c. g. s. system, but has rejected the usual convention by which the use of a long line of ciphers is avoided.

11. *Absolute Measurements in Electricity and Magnetism;* by ANDREW GRAY, M.A., etc. 207 pp. 12mo. London, 1884 (Macmillan & Co.).—The universal adoption by electricians of the series of electrical units, based upon the absolute system, which was recommended by the Paris Congress of 1881, has served to put electrical measurements upon a basis of precision, which was impossible as long as the old methods were adhered to. This little volume of Mr. Gray starts with the explanation of the relations of these units, and goes on to develop the principles involved in absolute measurements, and the practical methods and instruments employed in them. The subject is one of great importance

at the present time, especially in view of the wide interest felt in the practical applications of electricity, and the excellence of this treatise cannot fail to be appreciated by all who use it.

12. *Heat;* by P. G. Tait, M.A., etc. 368 pp. 8vo. London, 1884 (Macmillan & Co.).—The well-known name of the author is a sufficient guarantee of the high character of this treatise, and those who take it up expecting to find an exceptionally clear and lucid exposition of the principles of this department of Physics will not be disappointed. The author states that the work is intended especially for students who have not a scientific career before them, but whose aim is to gain an accurate knowledge of the important facts and theories of modern physical science. For this class of students the work is admirably adapted in its clearness and simplicity of style, fullness of word illustration and logical development of the fundamental principles. It is, however, calculated to be of value to more advanced students, and those whose design is more strictly scientific, for there is a freshness in the method of treatment which makes it valuable and suggestive to all.

II. Geology and Natural History.

1. *Genera of Fossil Cephalopods;* by Professor A. Hyatt, (Proc. Boston Soc. Nat. Hist., xxii, April, 1883).—Professor Hyatt gives in this memoir the last results of his extended study of the Nautiloid, Ammonoid and other groups of Cephalopods. Of these results not the least important are his interesting deductions as to the genesis of the group, based on comparisons of the successive forms of the whorls in individual shells, and with the successive forms in geological time. He appears thus to prove the direct derivation of the Nautilus family and of the Goniatites from a kind having the shell a simple straight cone—the form of an Orthoceras—the *young* form in Goniatites as well as in Nautilus being of this kind. The remaining Ammonoids "skip" this simplest form, and those of Cyrtoceras and Gyroceras, in their development, but still bear evidence, in his view, that they are "descendants of the close-coiled Nautilinidæ." He states that "the generic terms *Cyrtoceras*, *Gyroceras* and *Nautilus* are really only descriptive terms for the different stages in the development of an individual, and for the different stages in the development or evolution of the series of adult forms in time;" that "each of these genera, as now used, includes representatives of all the different genetic series of Tetrabranchs;" that the earliest forms "agree in general aspect, owing to the proximity of the septa, but they do not agree in structure or in their embryos." The general conclusion is extended to the Belemnoid and Sepioid groups, but with less satisfactory proof.

Facts of the above-mentioned kind led Mr. Hyatt, several years since, to announce the "law of acceleration in development" as an explanation of quickened or abrupt steps under the theory of evolution, which he now prefers to designate the law of "con-

centration of development." He speaks of the sudden appearance of distinct types in Paleozoic and later time as an "acknowledged" fact; of distinct types as far most numerously evolved in Paleozoic type than later; of the field of variation as decidedly narrower in the Mesozoic than in the Paleozoic; observes that the separation of the grander groups under the general type took place rapidly in the Paleozoic; and states as deduced principles that "types are evolved more quickly and exhibit greater structural differences between genetic groups of the same stock while still near the point of origin than they do subsequently;" that important characteristics disappeared with the progress of a type, often abruptly, in accordance with the law of concentration of development and of increase in concentration with the progress of the group.

Mr. Hyatt makes no reference to the vastly greater length of Paleozoic than Mesozoic time—probably not less than five times longer, if not ten—which fact bears on the value of such deductions.

The uncoiled forms which occur in the later part of Mesozoic time are recognized as degraded or retrogressive forms, the embryonic forms in all these uncoiled kinds being coiled; and the return to the earlier Paleozoic forms is made part of the proof as to the derivation of the group from those early species.

In connection, he makes the following reasonable statement:

"Slaves of the embryological lamp consider that they must associate all forms which have similar embryos, and dissociate in classification all forms having different embryos. As a matter of experience the surest guides of affinity are the adult gradations of forms. These show that the Nautiloidea and Ammonoidea, with comparatively distinct embryos, are nevertheless more closely related than the Belemnoidea and Ammonoidea which have precisely similar embryos, and that Sepioidea and Belemnoidea, which have very distinct embryos, must also be closely affiliated."

The principle "acceleration in" or "concentration of development," which has been put forward also by Professor Cope, is an expression in a general form of the idea that there were abrupt steps in the line of progress and to some extent an explanation of it. But we have yet to learn the wherefore as to such abrupt steps.

2. *The Geological History of Serpentines, including Studies of Pre-Cambrian Rocks;* by T. Sterry Hunt. Trans. Roy. Soc. Canada, i, section 4. 1883. Montreal.—Dr. Hunt, reviewing a subject he has treated in former papers, presents here some of the facts connected with the serpentines of North America, and other facts from those of Europe, and his deductions: (1) that serpentine is never a true eruptive rock, and (2) is of aqueous origin. The former conclusion is well sustained; the latter might have been discussed with much greater thoroughness; for the best facts on the subject are overlooked. No sufficient use is made of the

many examples of the derivation of serpentine by alteration from pyroxene, hornblende, enstatite, chlorite, and nothing adequate to the importance of the subject as to its derivation from chrysolite and chondrodite. Under the head of "Serpentines in North America," the author might have cited many more facts than he has done from North Carolina, where the origin of serpentine is illustrated on a grand scale and with details that are exceedingly instructive. Other facts might have been given from the Tilly Foster Iron Mine, at Brewster, New York, where the change of chondrodite (a magnesia silicate containing fluorine) to serpentine is exemplified with wonderful fullness; where white dolomite sprinkled with grains of chondrodite has in some parts the grains partly and in others wholly altered to serpentine; where crystallized chlorite, enstatite and other minerals have participated in the change and show all shades of gradation in it; and where brucite (magnesia hydrate), fluorite (calcium fluoride), and magnetite in fine crystallizations occur as results of the changes that went forward as a consequence of the chemical conditions; where a nearly white serpentine often occurs clouded in spots with black, due to microscopic grains of magnetite, derived apparently from the excluded iron of the chondrodite, these and other similar facts suggesting a possible source for the magnetite of other serpentines. The author describes the New Rochelle serpentine after a visit to the region, but he omits to mention that tremolite, or a white to pale green hornblende occurs abundantly in all stages of gradation in composition between these minerals in the unaltered state and serpentine, and that enstatite or a closely-related mineral is another of the half-altered to wholly serpentinized species. For right conclusions with regard to the origin of serpentine and its relations to the associated rocks there must be a thorough study and consideration of this class of facts, which is here neglected almost *in toto*, although abundantly represented in Europe as well as America.

3. *The Taconic question in Geology;* by T. Sterry Hunt. Part I. Transactions of the Royal Society of Canada. Volume i, section 4, 1883, Montreal.—The deficiencies and one-sidedness of the historical review in this "Part I" are so great that the views cannot be properly considered before the appearance of the closing "part." The subject has been the topic of former publications by the author.

4. *Results of an Examination of Syrian Molluscan Fossils, chiefly from the Range of Mt. Lebanon;* by Charles E. Hamlin. 68 pp. 4to, with 6 plates. Volume x, No. 3 of the Mem. Mus. Comp. Zool. Cambridge, Harvard College. Cambridge, April, 1884.—After speaking of the publications on the fossils of Palestine by Conrad (Dead Sea Exploring Expedition under Lieut. Lynch), L. Lartet, in 1869–1872, and Professor Oscar Fraas in 1867, 1877 and 1878, Mr. Hamlin observes:

"The most important consequence of the labors of Lartet and Fraas is the change of view which they have brought about with

respect to the age of the stratified rocks of Palestine and the Lebanon region. It is now an established fact, that the great Cretaceous system which, stretching in northern Africa through Morocco and thence eastward to Egypt, and southward into the Sahara and the Libyan desert, crosses over into the peninsula of Sinai, spreads also over the greater part of Palestine and the ranges of Lebanon and anti-Lebanon, and probaby prevails east of the Jordan and the Dead Sea, in Gilead, Moab, and Idumæa. The earlier explorers seem to have been misled by the strong external resemblance of the light-colored limestones which they observed in Palestine to the rocks of the White Jura of Europe, and therefore regarded them as Jurassic."

The species described and well-figured in Mr. Hamlin's paper are Cretaceous, and probably later than the Cenomanian stage. As to the Tertiary formation, he states, from Fraas and Lartet, that the Eocene occurs in Syria south of Tarabulus (Tripoli); but that, according to Fraas, it is impossible to draw the limit between the Cretaceous and the Eocene, since it is found that Nummulites pass down into the Cretaceous.

5. *Recherches sur les Terrains Anciens des Asturies de la Galice (Spain)*, par CHARLES BARROIS. 630 pp. 4to, Lille, 1882. —This volume is the report of an extended and careful study of the Paleozoic and underlying rocks of this part of Spain, of its rocks, its stratigraphy and its paleontology, and of the phenomena that have modified the Paleozoic strata since their formation. It is illustrated by an atlas in quarto containing sections, views, and many plates of fossils. The author states that the Primordial or Cambrian group passes gradually into underlying crystalline schists without unconformability or any abrupt lithological change. The Primordial includes argillytes and fine-grained mica schists (which are sometimes staurolitic, chloritic and occasionally contain tourmaline) together with quartzyte or sandstone, and limestone.

The upturning of the series of beds in the Cantabrian Mountains is attributed to lateral pressure, and occurred, as he shows, at or toward the close of the Carboniferous, acting in the direction of the parallels of latitude.

The Mesozoic beds overlie the upturned edges of the Carboniferous, and the strata are conformable to the top of the Eocene, a fact indicating that the next great epoch of disturbance after that closing Paleozoic time in Cantabria occurred after the Eocene and was identical with that which determined the relief of the Pyrenees (p. 604). The pressure was nearly in the direction of the meridians from north to south. The features of the region are chiefly due to the results of this post-Eocene disturbance, for it not only caused the elevation of the Mesozoic beds, but also modified sensibly the relief of the Paleozoic masses, and produced the great difference of level between the coal beds of the Asturias, which are worked even below the sea-level at Arnao, and those of the Cantabrian chain in which they have a

height of 2000 meters. The author draws attention to the fact of the transverse directions in the great uplifts of the two mountain-making disturbances.

Mr. Barrois detected coccoliths in the Devonian rocks and concluded that these microscopic convex or plano-convex disks are of inorganic origin and not organic (p. 46). The Paleontological part of the volume contains many observations of wide interest, but there is not space here for a review of them.

6. *Catalogue of the Fossil Sponges in the Geological Department of the British Museum (Natural History), with Descriptions of new and little-known species*, by GEORGE J. HINDE, Ph.D., F.G.S. 248 pp. 4to, with 38 lithographic plates.—The remarkable fullness of the British Museum in its collection of fossil sponges has enabled the learned author of this volume to make a general review of the subject and contribute largely in species and facts to this branch of paleontology. The genera represented by species in the museum are 141 in number; of these 120 are of Siliceous sponges, and the rest of Calcareous; 32 species are from the Paleozoic, 16 from the Triassic, 96 from the Jurassic, 245 from the Cretaceous and 3 from the Tertiary. The many plates are well filled with excellent figures. The text closes with a full bibliography.

7. *Origin of the Italian Serpentine;* by B. LOTTI (Boll. R. Com. Geol. Ital., 1883, p. 11, 12).—The author of this paper reviews the facts connected with the subject, and the opinions of authors, and concludes that the "Pre-silurian Serpentine," which on Elba is interstratified with crystalline calcareous schists, and is in thin alternating beds at other localities, has proceeded from the transformation of pyroxenic, hornblendic, dioritic, etc., schists, which were originally of sedimentary origin; while the Eocene serpentines have been produced by the alteration of the eruptive rocks, diabase and dioryte, or of euphotide, which he is inclined also to place in this class of rocks.

8. *Phosphatic deposits in the Cretaceous of Alabama.* — A letter to the editors from Professor Eugene A. Smith, State Geologist of Alabama, reports the discovery of important deposits of phosphatic nodules and green-sand beds at Hamburg in Perry County, at the base of the Rotten limestone. The Rotten limestone is represented only by its lowermost beds. Below it, occur (1) green-sand beds, 1 to 4 or 5 feet thick; (2) about 6 feet of sandy calcareous beds containing hard phosphatic nodules which vary in diameter from that of a pea to an inch or more, associated with various fossils, species of Nautilus, Ammonites, Baculites, and other well known species, the shells to a considerable extent phosphatic, vertebræ and other bones, large pavement teeth of Cestracionts; (3) one foot to 18 inches of light-colored sandy marl, averaging 10 per cent in its phosphoric acid; (4) whitish calcareous and micaceous sands, holding small oyster-shells, with some phosphate, and, below a level of 20 to 30 feet, compact bluish sands in which there is considerable green sand. The

letter states the probability that these phosphatic beds are continued beneath the Rotten limestone across the State of Alabama, through Eutaw and other places to Farmington in Mississippi. Green sands from Eutaw have been found on analysis to contain 8 per cent of phosphoric acid.

9. *Allgemeine und chemische Geologie* von JUSTUS ROTH, Zweiter Band, erste Abtheilung: allgemeines und ältere Eruptivgesteine. pp. 1 to 210, 8vo. Berlin, 1883 (Wilhelm Hertz).—This first part of the second volume of Roth's very valuable work is devoted to a preliminary discussion of rock-structure, and further, to a description of plutonic and older eruptive rocks.

10. *Third Annual Report of the State Mineralogist of California*, for the year ending June 1, 1883. 111 pp. 8vo. Sacramento, 1883.—Part 1 contains the Report of the State mineralogist, Mr. Henry G. Hanks, as to the condition of the California State Mining Bureau. Part 2 contains a very full report on the borax deposits of California and Nevada, in which Mr. Hanks has brought together a large amount of useful and valuable information bearing upon all the topics concerned in the borax industry of especial practical value to Californians and to others interested in the production of borax. This report contains, in addition to the matter compiled from many sources, the results of personal observation by the author as well as a considerable amount of laboratory work; a map is given showing the principal localities in the two States mentioned.

11. *Brief Notices of some recently described Minerals.*—COLEMANITE is a hydrous borate of calcium, probably identical with priceite. It occurs in monoclinic crystals, with a prismatic angle of $108\frac{1}{4}°$, also massive. The cleavage is clinodiagonal, perfect, affording thin smooth laminæ. Hardness 3·5 (amorphous), 4·25 (crystals); specific gravity 2·428. Luster vitreous to adamantine. Transparent to subtranslucent. An analysis yielded

B_2O_3	CaO	H_2O	
[50·98]	27·18	21·84	= 100

Small amounts of soda were found, even in the clearest crystals, which was regarded as due to mechanical admixture, and the suggestion is made that the mineral may have been formed from ulexite. Colemanite was found in Southern California, and named after Wm. T. Coleman of San Francisco; described by J. T. Evans in the Bulletin of the California Academy of Sciences, Feb., 1884.

BRÖGGERITE.—This name (after the Norwegian mineralogist, W. C. Brögger) has been given by C. W. Blomstrand to a uranium mineral near cleveite, both of which are allied to uraninite. The specimen examined is from the neighborhood of Moss, Norway; it formed part of an octahedral crystal having an iron-black color, with hardness 5 to 6, and specific gravity 8·73. An analysis afforded

UO_3	UO_2	PbO	ThO_2	Cerium earths.	Yttrium earths.	FeO	CaO	SiO_2	H_2O	
38·82	41·25	8·41	5·64	0·35	2·42	1·26	0·30	0·81	0·83	= 110·12

For this the author writes the formula UO_2, RO, UO_3 or more exactly $6URO_6U + U_3(O_6U)_2$, in which the R includes the thorium, cerium and yttrium earths and lead. The author gives an extended discussion of the constitution of the related uranium minerals.—*Geol. För. Förh. Stockholm*, vii, 59, 1884.

ALLAKTITE.—A mineral described by A. Sjögren as occurring in small tabular monoclinic crystals, flattened parallel to the orthopinacoid; according to H. Sjögren it is near in form to members of the vivianite group. Hardness 4–5, specific gravity 3·83–3·85. Color yellow to green. Strongly pleochroic (whence the name). An analysis afforded

As_2O_5	MnO	FeO, MgO, CaO	H_2O	
28·57	61·92	1·15	9·01	= 100·65

For this formula $7MnO, As_2O_5, 4H_2O$ is given. It occurs with other manganese minerals at the Moss mines in Nordmark, Sweden.—*Geol. För. Förh. Stockholm*, vii, 109, 1884.

SALMITE.—A manganesian variety of chloritoid from Vielsalm, Belgium, described by Eug. Prost (Geol. Soc. Belg.) It occurs in irregular masses with coarse saccharoidal structure and grayish color. Hardness 5 to 6, specific gravity 3·38 of material containing a little quartz. An analysis afforded

Si_2O	Al_2O_3	Fe_2O_3	FeO	MnO	CoO	MgO	CaO	H_2O	Quartz.	
19·14	33·66	3·38	13·05	7.14	0·04	1·79	0·30	6·32	15·06	=99·88

12. *Clematides Megalanthes, Les Clématites a Grand Fleurs: Description et Iconographie des Espèces cultivées dans l' Arboretum de Segrez;* par ALPHONSE LAVALLÉE. Paris, 1884. (Baillière.)—A sumptuous volume, in imperial 4to, of 84 pages and 24 plates, from drawings by Bergeron, in the form and style of the Arboretum Segrezianum of the same enterprising and liberal-minded author. It is well for science when an individual has the capacity and the public spirit to carry on such an undertaking as the Arboretum of Segrez and the publications which illustrate both its treasures and the botanical acumen of its founder.

The first section of this work is occupied with the investigation and iconography of the Japanese species of *Clematis*, such as *C. patens*, *C. florida*, etc., which have of late years become so attractive in cultivation, and which especially deserve the name of great-flowered Clematis. But the scientific interest to us centers in the North American species, and in some cultivated species of doubtful origin, which may have American blood.

M. Lavallée figures and describes as distinct species, *C. cylindrica* Sims, Bot. Mag., and *C. crispa*, L. Very probably this is a correct view, although we had put the two together. The latter we have had in cultivation, the former we know only in dried specimens; and they seemed to pass into each other. We commend these species to the attention of our botanists of the middle and southern Atlantic States, and ask for living plants and good dried specimens in flower and fruit. The *C. distorta* which Lavallée figures, from a cultivated plant of unknown

origin, seems to us to represent something between the two above-mentioned species or forms, more or less modified by long cultivation. Of the two old figures which he refers to it, that from Bot. Mag. t. 1892, we should say belongs to his *C. crispa*, and that from Bot. Rep. t. 71, to *C. cylindrica*. As to *C. erioste-mon* of Decaisne, the *C. Hendersoni* of the gardens, we cannot think that this is at all of American origin, and we hold to our former guess that it is a hybrid of *C. Viticella* and *C. integrifolia*.

C. Viorna and *C. reticulata* are well figured, the latter in a form with under-sized flowers. *C. Pitcheri* is well figured in one of the larger-flowered forms; and the new *C. Sargenti*, if we are not much mistaken, is only a smaller-flowered form of the same species.

C. Texensis Buckley is the name preferred to *C. coccinea* of Engelmann, on the ground that the former is the earlier published. We think quite otherwise, though there is room for question. Buckley's name was published in 1863. But he had before him the second part of *Plantæ Wrightianæ*, published in 1852, in which the present writer, although he called the plant *C. Viorna* var. *coccinea*, yet published Engelmann's name "*C. coccinea* n. sp., Engelm. MSS.," and added the essential characters which distinguish the species. It is clear to us that this characteristic name (under which the plant is cultivated and has been more than once figured,) was truly published in 1852, and therefore should be retained.

In reprinting the notes upon the American large-flowered species of *Clematis*, contributed by the present writer to the Botanical Magazine in the year 1881, at the foot of page 70, a portion of the penultimate sentence under *C. reticulata* has been accidentally dropped in transcription and the last sentence joined to the preceding one, so as quite to spoil the sense.

An appendix gives a brief review of the tubular-flowered species, lately in controversy, in which M. Lavallée corrects the determinations of the lamented Decaisne in some respects.

A. G.

13. *Porto Rico plants.*—A botanical exploration of this island is undertaken by P. Sintenis under the direction of Dr. T. Urban, of Schœneberg, near Berlin, who wishes to receive the names of subscribers, at 30 marks ($7.50) per hundred specimens, payable on delivery. The mountains of Porto Rico ought to yield a good harvest. A. G.

14. *Erythrææ Exsiccatæ quas distribuit* V. B. Wittrock, Director Musei Botanici Stockholmiensis, Fasc. I, 1884.—This is the beginning of a complete autotype illustration of a genus which, though not large, abounds in critical species and forms; and the North American species doubtless need similar investigation and illustration. Dr. Wittrock informs us that, if he can secure specimens from this country, in sufficient abundance, he will include them in the beautiful work which he has now begun. For the indigenous species we must appeal to botanists of our western

regions, from Arkansas and Texas to the Pacific Coast. Their contributions, which are hereby solicited, will be repaid in kind. Botanists who are willing to extend their aid and who are desirous of details, may communicate with the writer of this article, at Cambridge. The present fascicle, a thin folio volume, is devoted to the *E. vulgaris* type, in its various forms A good woodcut figure of corolla and stamens is given on the leading ticket of each species. A. G.

III. Miscellaneous Scientific Intelligence.

1. *The British Association at Montreal.*—The meeting of the British Association at Montreal will commence on Wednesday, August 27. The reception rooms will be open on the Monday preceding at 1 P. M., and on the following days at 8 A. M., for the issue of tickets to members and associates (and ladies), and for supplying information as to lodgings, etc. The general secretary of the executive committee is Mr. J. D. Crawford. The tickets will contain a map of Montreal, and particulars as to the rooms appointed for sectional and other meetings. A general meeting will be held Wednesday evening, opening at 8, at which President Cayley will resign the chair and the Right Hon. Lord Rayleigh, President-elect, will assume the presidency and deliver an address. On Friday evening there will be a discourse by Professor W. G. Adams, and on the evening of the following Monday a discourse on "The modern microscope in researches on the least and lowest forms of life," by the Rev. W. H. Dallinger; on Saturday evening a lecture on comets, for the citizens of Montreal, will be delivered by Professor R. S. Ball, of Dublin University.

Contributors of papers to the meeting are required (under an arrangement dating from 1871), to send to the "General Secretaries of the British Association," 22 Albemarle street, London, W., an abstract of the paper, suitable for insertion in the transactions of the association, together with the paper, with a statement as to the section for which it is intended, that the committee may decide, in advance of the time of meeting, as to the acceptance and time of reading.

The Local Executive Committee has issued the following circular with regard to membership and the enrolling of new members:

(1) Life members for a single payment of $50, which entitles them to all the privileges of membership for life, and to receive all reports which the association may publish after the date of payment.

(2) Annual members for a payment of $10 the first year ($5 of which is the entrance fee), and $5 each consecutive year thereafter, with the same privileges as life members.

(3) Associate members for a payment of $5. Associates are not eligible to hold office in, or to serve on any committees of the Association; nor do they receive the annual reports. All other privileges of membership for the year are open to them.

Persons who are already members of the Association may be re-enrolled by paying the annual dues of $5. Life members will be re-enrolled without payment. No person who is not a member is admitted to any of the meetings of the Association. The privilege of reduced fares by the railway and steamboat lines is limited to the life, annual and associate members. Applications for admission to membership may be addressed to Mr. J. D. Crawford, General Secretary of the Citizens' Committee, Post-office box 147, Montreal.

The Circular is signed by THOMAS CRAMP, Chairman, and DAVID A. P. WATT, Secretary, and dated Molsons' Bank Chambers, 198 St. James street, Montreal, April 15, 1884.

2. *American Association.* — The Philadelphia meeting of the American Association commences its session on the 3d of September, under the presidency of Professor J. P. LESLEY. The vice-presidents of the sections are: A, Mathematics and Astronomy, H. T. EDDY, of Cincinnati; B, Physics, JOHN TROWBRIDGE, of Cambridge; C, Chemistry, JOHN W. LANGLEY, of Ann Arbor; D, Mechanical Science, R. H. THURSTON, of Hoboken; E, Geology and Geography, N. H. WINCHELL, of Minneapolis; Biology, E. D. COPE, of Philadelphia; F, Histology and Microscopy, T. G. WORMLEY, of Philadelphia; H, Anthropology, E. S. MORSE, of Salem; I, Economic Science and Statistics, J. EATON, of Washington.

The Permanent Secretary of the association is Professor F. W. PUTNAM, of Cambridge; the General Secretary, ALFRED SPRINGER, of Cincinnati; the Assistant General Secretary, E. S. HOLDEN, of Madison; the Treasurer, WILLIAM LILLY, of Mauch Chunk.

3. *Peabody Museum of American Archæology and Ethnology of Cambridge, Mass., 16th and 17th Annual Reports.* Cambridge, 1884.—American Archæology is making rapid progress through the labors of Professor Putnam and the work and publications connected with the Harvard Peabody Museum. The volume issued contains various original papers besides the report of the curator. A few facts are here cited from it:

(1) The *meteoric iron* "found on the altar of mound No. 3, of the Turner group of earthworks in the Little Miami valley, Ohio, has been analyzed by Dr. L. P. Kinnicutt. One piece was found to have G.=6·42, and to consist of Iron 86·66, nickel 12·67, cobalt 0·33, copper *trace*, insoluble residue 0·10; the second specimen, to have G.=6·51, and to consist of Iron 88·37, nickel 10·90, cobalt 0·44, copper and phosphorus *traces*, insoluble residue 0·12. Each contains small crystals of olivine, and the former also a little bronzite. A polished piece of the first gave well-marked Widmannstättian figures, and the second appeared to be of the same character. The other specimens were similar, in containing nickel, proving that all the iron from the mound was of meteoric origin.

Another mass of iron weighing 767·5 grams, from the altar in mound No. 4, of the same group, contained large concretions of

olivine, like the "pallasite" section of meteoric irons, and had a specific gravity, according to a determination by Professor Lattimore, of Rochester, N. Y., of 4·72. An analysis of the iron by Mr. Kinnicutt afforded Iron 89·00, nickel 10·65, cobalt 0·45, copper and phosphorus *traces;* of the olivine, Silica 40·02, iron protoxide 14·06, manganese protoxide 0·10, magnesia 45·60. Specific gravity of the olivine, 3·33; of the iron, 7·894. Small grains of bronzite were detected.

Mr. Kinnicutt states that the external resemblance of the specimen to those of the Atakama iron is striking. Buchner's analysis of the iron of the latter gave Iron 88·01, nickel 10·25, cobalt 0·70, phosphorus 0·33, sodium 0·21, potassium 0·15, and G.=7·44–7·66; which is very near that of the Ohio-mound iron. The olivine, according to an analysis by Schmid, contains only 36·92 per cent of silica; but the analysis needs revision, since the iron and manganese are given as sesquioxide, and if reckoned as protoxide (its condition in unaltered olivine), the analysis shows a large loss.

(2) *A human molar tooth* has been found by Dr. C. C. Abbot *in the gravels near Trenton affording paleolithic implements.* It is a rolled and worn tooth, and is therefore of the same age with the implements. Dr. Putnam says that the discovery of the tooth removes the little doubt there was about the gravel-bed origin of the portion of a human skull obtained some years since at Trenton by Dr. Abbot from a person who stated that it was found in the gravel.

Professor Putnam, in the course of his report, adds a word on (3) *fraudulent antiques.* He says that Indian pipes, dishes and other relics are made for the ethnological market in Philadelphia; a large business has been done in Ohio in the so-called gorgets cut from slate and in hematite celts; and much Indian pottery has been put into the trade in southern Illinois. A carved stone representing a naked child was recently sent from Eureka, in Arkansas, to the Peabody Museum for sale, which "proved to be a child of the 'Cardiff Giant' family."

4. *The Güegüence, a comedy ballet in the Nahuatl-Spanish dialect of Nicaragua;* edited by D. G. Brinton. 96 pp. 8vo. Philadelphia, 1883. *Aboriginal American Authors and their Productions;* by Daniel G. Brinton, A.M., M.D. 64 pp. 8vo. Philadelphia, 1883. Brinton's Library of Aboriginal American Literature.—These two volumes are works of much research and historical interest, by one of the ablest of American archæologists.

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